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WASTE HEAT RECOVERY IN REMOTE COMMUNITIES:
A Shared Opportunity



Waste Heat
Recovery In
Remote
Communities –
a shared opportunity

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1988

Ce document est disponible en français sous le titre suivant:
La récupération de la chaleur perdue dans les collectivités éloignées-
des avantages pour tous.

© Minister of Supply and Services Canada 1988
Catalogue No. M91-7/30 1988E
ISBN 0-662-16464-4

PREFACE

Canada's remote communities are unique. Differences in lifestyles, social and economic conditions, as well as geography and climate, serve to set these communities apart from the rest of Canada. They are also different in terms of energy needs and energy options. Many are entirely dependant on diesel generated electricity. Fortunately, there are new opportunities to improve the energy situation through energy conservation and alternative energy technologies. One of these options involves the recovery of heat produced by diesel generator sets for space heating in nearby buildings, thereby saving valuable space heating fuel without compromising electrical service.

With this in mind, this manual has been prepared for remote communities by Acres International Limited with funding from the Remote Community Demonstration Program (RCDP) of Energy, Mines and Resources (EMR) Canada. It is hoped that this information assists those willing to undertake practical energy conservation alternatives which will result in energy and cost savings as well as providing better electrical service for consumers.

EMR Canada established the Remote Community Demonstration Program to help remote communities, and agencies responsible for their energy supply, to identify more appropriate energy alternatives and energy conservation opportunities.

The information in this manual is based on Acres corporate experience, information provided by utilities across Canada, literature searches, and discussion with diesel waste heat recovery contractors and with government agencies. This manual was produced in consultation with the Canadian Electrical Association Research and Development Program.

Acres would like to thank all of the people who contributed to this manual; their assistance and cooperation is sincerely appreciated.

SUMMARY

"Waste Heat Recovery In Remote Communities: a shared opportunity" is intended to assist residents of remote communities, utilities and governments in developing the potential of the rejected heat from diesel electric generating plants. The objectives are to promote interest discussion and action within this wide audience by raising awareness of the steps in a project, requirements, constraints and areas of interest and concerns. Written for a non-technical audience, the following is a summary of the chapters of this manual.

- Chapter 1 Describes the perspective from which this manual was written and how the manual can be used. It also briefly describes the major parts of a waste heat recovery/distribution (WHR/D) system, as well as the benefits of utilizing recovered heat.
- Chapter 2 Describes the WHR/D system installed at the Attawapiskat Hospital, by Ontario Hydro and the James Bay Hospital Board. The system and the steps taken to put the project in place are outlined, along with the project's costs and resulting benefits.
- Chapter 3 Provides a step-by-step example to guide participants through the usual course of a typical project. This briefly describes the planning, construction and operational phases of a WHR/D project, indicating which actions are required during each phase.
- Chapter 4 Deals with project management considerations, describing how a committee should be formed and organized to develop and manage a typical WHR/D project. The emphasis is directed at defining the work involved, work sharing, control of project work and project decision making.

- Chapter 5 Deals with the financial considerations involved in the decision making process. Briefly describes how project costs are derived and how they can be controlled. Methods of funding projects are given as are considerations for the financial evaluation of projects.
- Chapter 6 Deals with the economic and social considerations involved in the decision making process regarding use of funds for projects.
- Chapter 7 Addresses a typical project from a technical standpoint, describing the value of feasibility studies, planning and processes involved in project management, such as engineering design, procurement, construction and commissioning.
- Chapter 8 Describes the legal considerations of a project, including the development of a Heat Supply Agreement, third party contractor involvement, equipment and material contracts and right-of-way acquisition.

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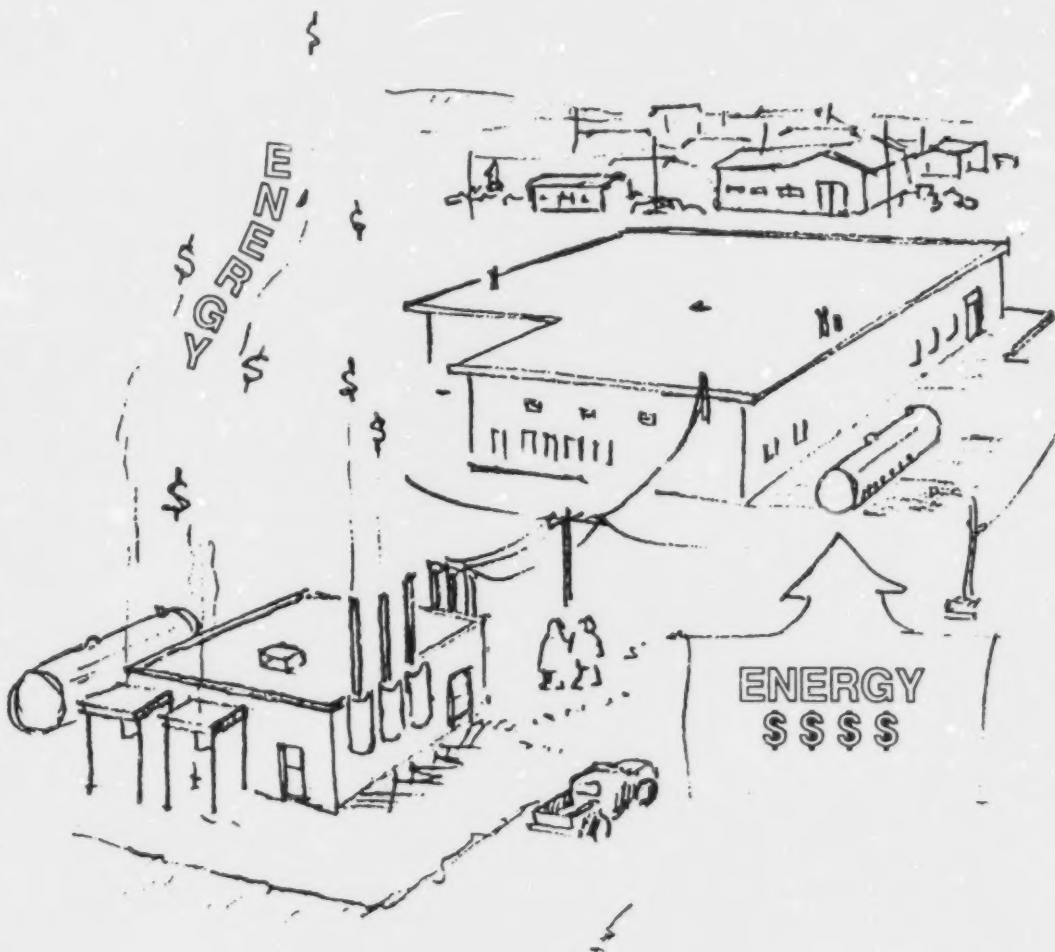
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Introduction



I - INTRODUCTION

This manual is intended to facilitate interaction and communication between electric utilities, community organizations and government agencies in remote communities who are considering using diesel power plant waste heat recovery technology.

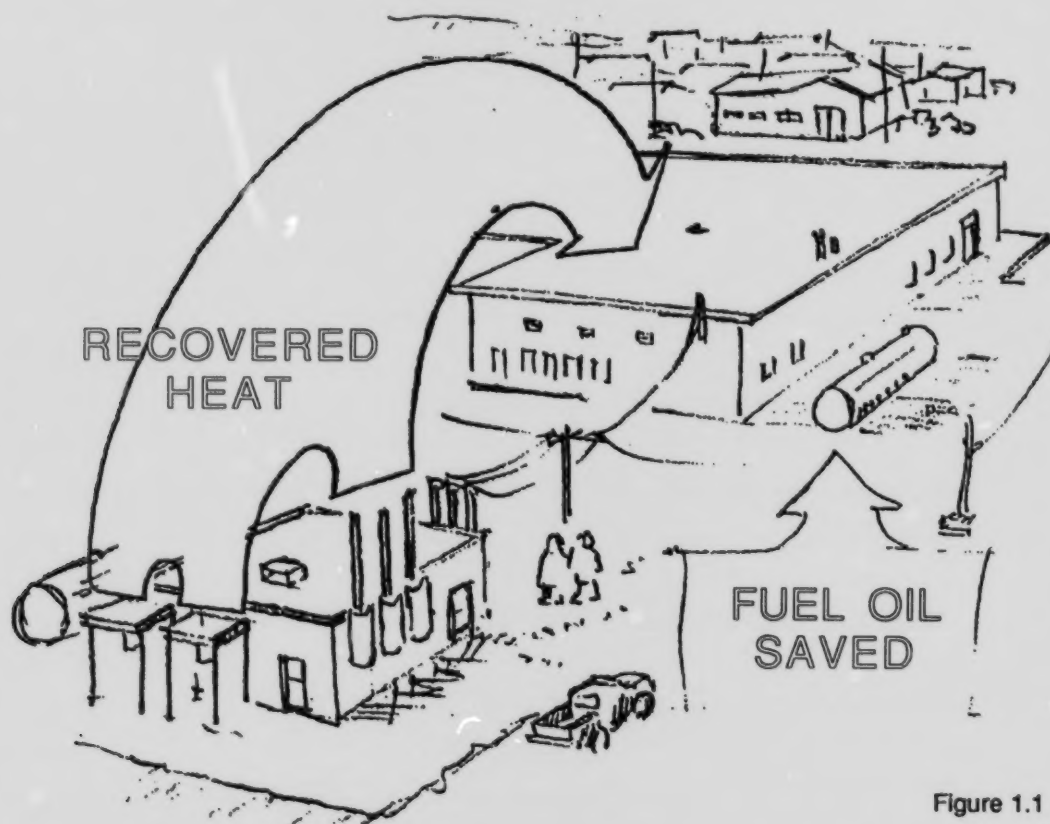


Figure 1.1

HEAT CAN BE RECOVERED FROM
DIESEL RADIATORS AND EXHAUST

How many people are aware that the oil used to generate electricity can also provide heating at a lower cost than using heating oil? For every one kilowatt of electricity produced by a diesel-powered generator, two kilowatts of heat are also produced. Without heat

recovery, this heat is carried outdoors by the diesel's cooling system and exhaust. This valuable heat can be recovered to serve many useful purposes. For example, the heat given off by a 200 kW diesel can heat both a 4000 m² school and a 5000 m² community building.

There are several well written technical manuals describing the operation of Waste Heat Recovery/Distribution (WHR/D) systems as well as sample cases of several successful installations (See Appendix D). However, we found that these sample cases and technical descriptions did not answer questions such as:

- "How do we get a project like this started, and if we can get it started, how do we keep it going?";

- "How can we get a productive discussion going among the electric utility, the governmental agencies and/or the community?";

- "What do we talk about and who do we talk to?";

- "How do we make sure we don't end up spending a lot of money for nothing?";

- "Who can help us with these matters?";

- "Are the benefits worth the cost?".

This manual will help to answer these and other questions that communities, agencies and utilities encounter while considering the installation of a WHR/D system. Building an installation is relatively easy compared to getting a project started and establishing a Heat Supply Agreement.

Many of these barriers to starting a project are not technical or financial. Instead, they are associated with lack of awareness, lack of communication and site specific problems.

If there are so many problems, why bother?

It may be the case that site specific problems in some communities may not allow development of a WHR/D system. However, in many other communities problems can be resolved by explaining, discussing, listening and understanding the interest and concerns of the groups involved. Cooperation and communication are the key. Past projects have demonstrated that the benefits of installing a WHR/D system outweigh the drawbacks. In these cases, WHR/D heat users have saved 25% of their annual fuel bill while receiving the same, if not more, heating value for their money.

The information presented in this Manual is based on discussions with government agencies, equipment suppliers, provincial or territorial utilities and heat users. It describes, in general, the current positive attitude towards WHR/D and explains how communities have successfully benefited from using recovered waste heat.

A. - How To Use This Manual

This manual provides a starting point for discussions between those who can use the recovered heat (user) and those who can supply the heat (supplier). It is a reference document:

- to getting the discussion started, identifying problems, and solving those problems;
- for recognizing when it is a good time to start looking at a WHR/D system;
- to figuring out whether or not the heat supplier or heat user could benefit from a WHR/D system;
- to developing an agreement between the supplier and user;

-for managing a WHR/D project to ensure that the installation is completed and that costs remain controlled;

-for commissioning and maintaining a WHR/D system.

A step-by-step process is provided to guide participants through an entire project indicating what to look for and what to do next.

B. - Description of a WHR/Distribution System

Many people are familiar with the diesel generating units and with the heat these units give off as shown in Figure 1.2

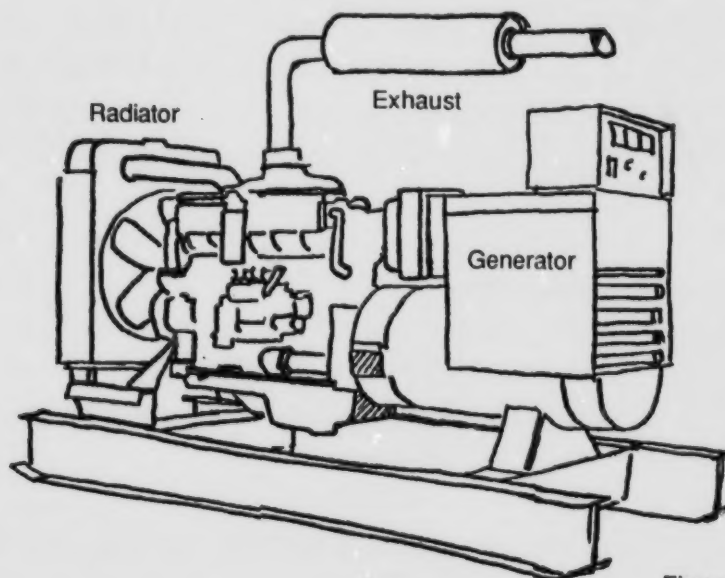
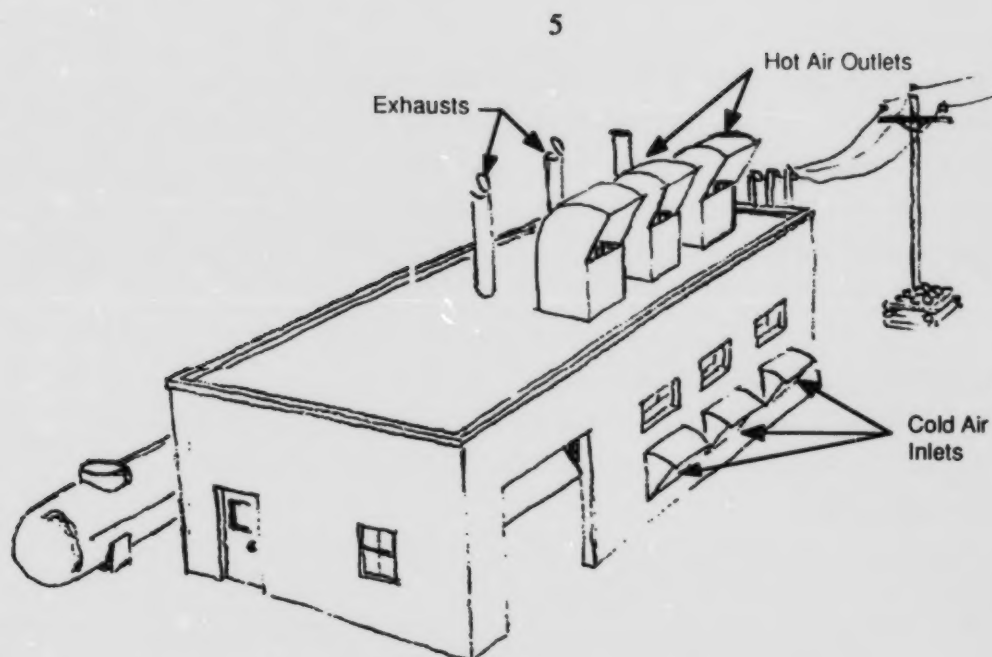


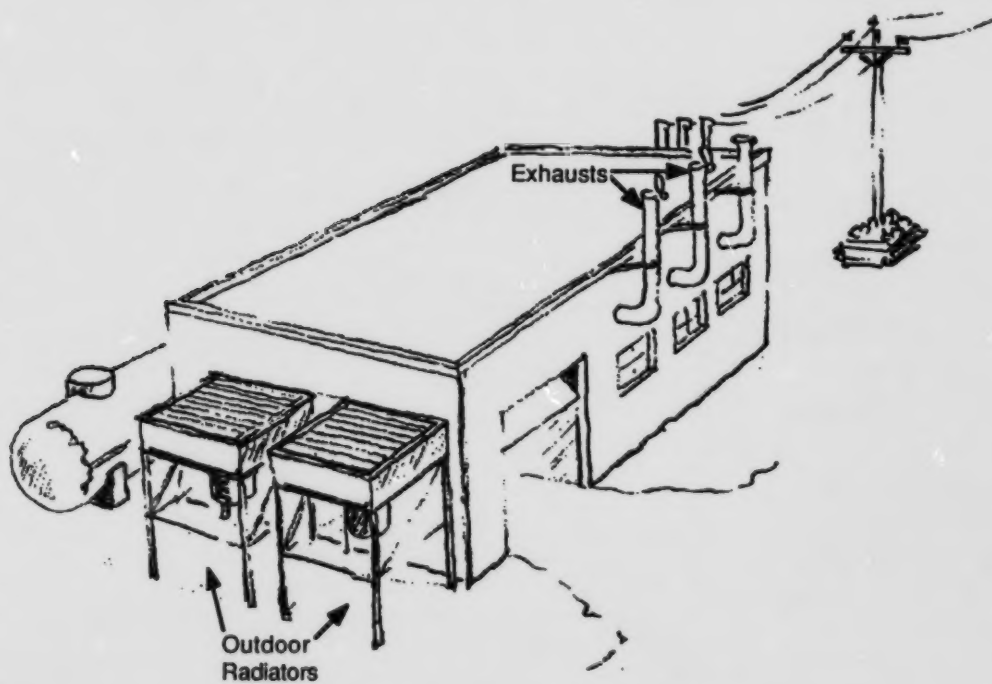
Figure 1.2

DIESEL GENERATOR

Consider the community's diesel generating plant. These diesel-powered generators have exhausts and radiators located outdoors as shown in Figure 1.3.



DIESEL PLANT WITH COOLING AIR DUCTING TO INSIDE RADIATORS



DIESEL PLANT WITH OUTDOOR RADIATORS

Figure 1.3

DIESEL GENERATING PLANTS

Heat can be recovered from both the diesel radiator coolant (jacket heat) and the exhaust (exhaust heat) by using heat exchangers. An exhaust heat recovery exchanger will almost double the total recovered heat but these exchangers are quite expensive. They are used where radiator coolant heat is insufficient to meet projected heat demand.

A WHR/D system takes the heat from the radiator coolant and exhaust then transports this heat through pipes to the location where the heat is required. A representative WHR and distribution system is shown in Figure 1.4.

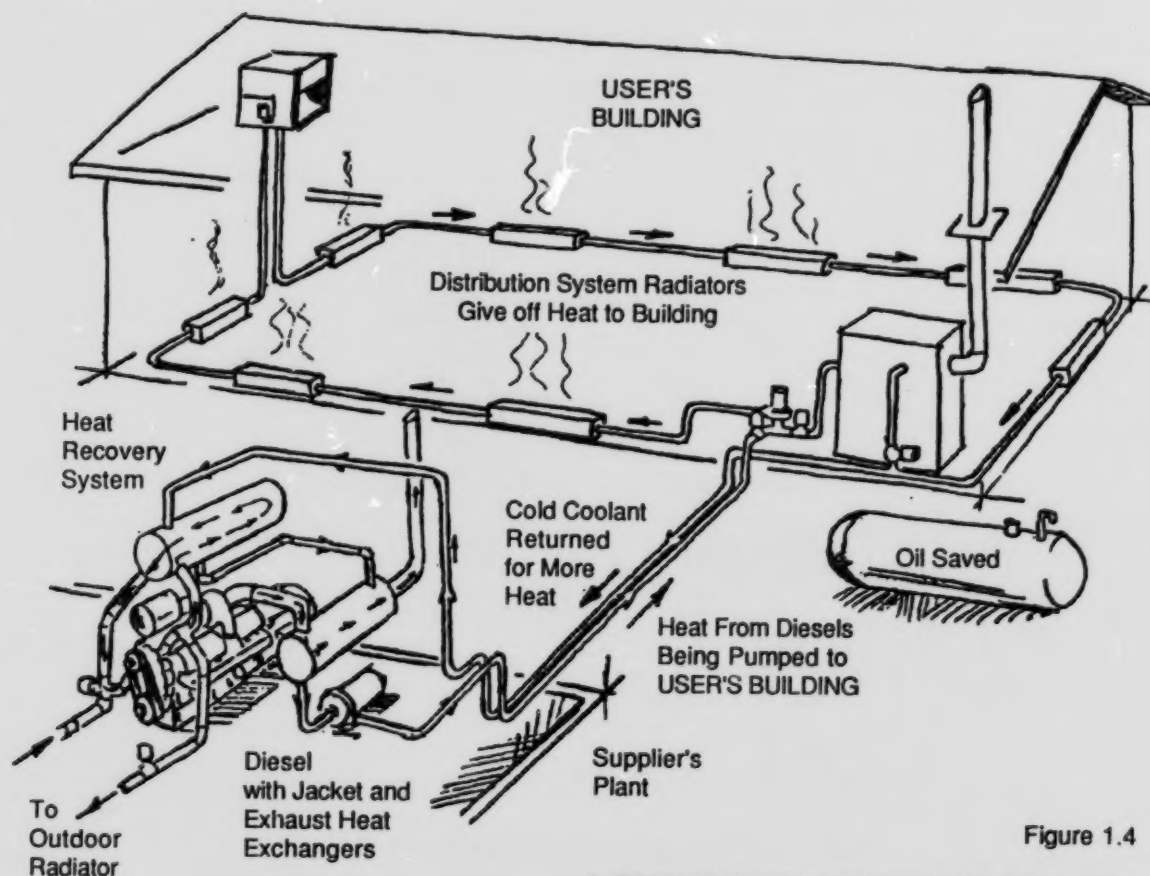


Figure 1.4

A REPRESENTATIVE WASTE HEAT RECOVERY
AND DISTRIBUTION SYSTEM

C. - Possible Benefits and Applications

User Benefits in General

A WHR/D system will provide continuing benefits. For example, over the period of one year a 365 kW diesel operating at 70% capacity can provide the same heat as 354 000 L of heating oil (1400 L/kW). If this recovered heat is piped through a distribution system to a school or a hospital, the heat user will not have to buy 354 000 L of oil each year. At \$0.58/L this is a savings of \$205,320. The amount of heating oil that can be saved will depend on the diesel size, the electrical demand and how the heat is used.

By using this reclaimed heat, users save 25% of their previous fuel costs as well as enough money to:

- pay for the new heat distribution system; and
- pay, if required, for the recovered heat used.

The amount each user saves depends on the Recovered Heat Supply Agreement negotiated with the heat supplier. In some cases, the supplier and user both install their own portions of the heat recovery and distribution system and a set rate is charged for the heat. In other cases, the user pays for all the heat recovery and distribution system costs and the heat is supplied free of charge.

Community Benefits

The installation of the WHR/D system provides employment for local labourers and contractors. The level of automation of these systems will require that local operating staff receive special training to use the new equipment efficiently. This brings new skills and capability to each community. The money that is not spent on oil (due to oil savings) may stay in the community to provide additional services needed by its residents.

Although intangible, the satisfaction of completing a WHR/D system is beneficial to community planning, cooperation and action. The methods and organization used to realize these energy savings can be equally applied to other community projects.

Government Agency Benefits

Government buildings and residences for government personnel may also be waste heat users. The savings in heating costs may reduce the level of funding required to provide current services, or may provide funds for additional or improved services.

Supplier Benefits

Compared to the user, the supplier benefits in most cases may not seem as great. Many suppliers contacted were prepared to give away the heat, providing the cost of the system and any additional operating costs were paid by the user. In addition, most suppliers have helped users in communities and are still willing to help these users with feasibility studies to determine the communities WHR/D potential and to develop the necessary systems.

The major benefit to these suppliers is knowing that this useful heat serves a beneficial purpose to users and that the money not spent on heating oil can be used for other needed services.

With the recovery system in place, the supplier can realize some savings by using part of the heat for the utility buildings, utility personnel housing and replacement of diesel block heaters as well as reduced operation of the radiator cooling fans. Since the diesel units cooling systems can be interconnected, the recovered heat can displace the block heaters on idle diesels. Each block heater typically draws an intermittent 5 kW of power. Radiator cooling fans may draw up to 7 kW intermittently. Diesel fuel is conserved through these load reductions.

Applications

There are many applications for recovered heat including building space heating, hot water, and freeze protection for water pipes and equipment. Space heating with recovered heat is suitable for buildings with large heating oil requirements such as schools, hospitals, residences, church missions, council meeting halls, hotels and large recreational facilities. Hot water can be generated up to 82°C (180°F) for laundry and household needs. Some communities use heat to protect their domestic water distribution and even their sewer systems from freezing. The recovered heat can also be used for the community's domestic water purification plant.

D. - The Supplier's Perspective

The heat supplier is the owner or operator of the electric diesel generating units. In general, these electric utilities have a positive attitude towards Waste Heat Recovery and would prefer to see this heat serve some useful purpose. Their primary responsibility to the community is to supply safe, dependable electricity. In providing this service, they will take steps to protect their equipment and to operate as efficiently as possible. Here are some of the problems encountered by heat suppliers in previous projects.

The first problem is dealing with three or four levels of government. In one case, four levels of government were involved in the same project. The project was postponed several times. Each time the project was restarted it was postponed for another reason. Someone had forgotten a permit, someone's financing had lapsed and had to be renegotiated, or someone wanted changes to the system. The project, which was to take six months, took two years to complete. Postponements add to the cost of the project, they create uncertainty and confusion.

The second problem is coordination of the many involved groups to get them to act together. The geographic distance between the

community and government or supplier groups and the problem of talking to people at a distance makes coordination difficult.

A third problem is communication, particularly problem solving communication. With any heat user it is important to discuss the idea of a WHR/D project with the user first. If they are not included in the project discussions from the outset, they may reject the idea totally and want nothing further to do with it.

The heat supplier is usually very familiar with WHR/D systems. To the user, WHR/D may be a completely new and unfamiliar idea. The supplier's concern is the lack of time and personnel to describe the idea of WHR/D to communities. It is hoped that this manual will fill this gap.

A further supplier concern is the additional workload placed on diesel operators. The level of automation of the WHR/D system should be matched to the ability of the operator to repair and maintain the additional equipment. Finally, there is the cost of installing the WHR/D system up to the user's distribution lines. These costs, in some cases, may prevent the supplier from providing the heat free of charge.

There is a limit to the amount of heat the supplier can provide. The amount of heat produced varies with the electrical load on the diesel. A higher electrical load will produce more heat. The supplier may put limits on his liability with respect to the user's system. For example, the supplier may not be able to guarantee that all of the user's heat requirements will be met 100% of the time. In these situations, the building's original heating equipment will be needed to supplement the WHR/D system's heat supply deficiency.

These interests and concerns will likely be raised during discussions while developing an agreement with the user.

E. - The User's Perspective

The heat user(s) is normally the owner or manager of a large community building. It is important to note that only large buildings should normally be considered for WHR/D as the cost of installing and operating such systems would not be economical for widely dispersed, single, small buildings, such as detached, single-family housing.

The user is interested in reducing heating costs. The problem of financing the distribution system may be an obstacle. Normally, the cost of the system is paid from the heating cost savings. In places where other methods of generating power are possible, there is the concern that the heat suppliers may change the source of power, rendering the expensive distribution system useless. In cases where there is potential for a power source change, the customer will likely ask for a long-term agreement with sufficient time to pay off the system and benefit from reduced fuel bills.

Users are also concerned about the possibility of project failure where the system is never completed or the completed system fails to deliver the calculated heat. There is also the problem of measuring the heat delivered. Some users may find it difficult to determine how much heat they need or how to figure out how many litres of heating oil the recovered heat will displace. This makes it difficult to determine the cost savings compared to the cost of the distribution system. Users are also concerned about possible interruptions in the supply of heat and the additional maintenance problems a distribution system would present.

These interests and concerns will likely be raised while developing an agreement with the supplier.

F. - Benefits of Cooperation and Planning

Cooperation: Why Cooperate?

By cooperating as committees or groups, people can both accomplish more and handle larger projects than individuals can on their own. Such benefits may require that each participant make adjustments to accommodate other participants' concerns.

Because these interests and concerns of both the supplier and the user must be heard and dealt with, effective cooperation is required to ensure a successful project. Both will need to provide information to each other and understand the other's limits, their operating conditions or restrictions. Discussions between the two groups are important to resolve difficulties and develop both cooperation and trust.

Pre-Project Investigation

The collection and organization of information at an early stage is extremely important as it forms the basis for all discussions and project planning.

These discussions would address needs including:

- lower heat costs;
- electrical production;
- community growth plans;
- access routes for pedestrians and vehicular traffic where an above-ground distribution system is considered.

The benefits of having information properly collected, organized, and located in a convenient meeting place are great because:

- it lets participants understand what information is available and makes it easier to figure out what additional information is required;
- having the information available saves time, avoids confusion (people won't argue about what they may think something is, with information available they will know for sure what it is) and avoids frustration (discussions will not be delayed because some important piece of information is missing);
- it allows participants to see and understand the whole idea rather than just a part of the idea. Understanding the whole idea reduces confusion and increases cooperation;
- it can reduce the cost of the project by helping the participants find the best system for their situation and by avoiding problems or mistakes made on similar projects by previous committees.

Planning

Planning is essential to all phases of a project:

- the tasks to be done should be listed in the logical order with the requirements of each task spelled out;
- each task should be given a date to begin and a duration of time in which the task must be completed;
- personnel and financial resources should be assigned to each task.

The benefits of planning are that the participants involved will have a better understanding of their role, their tasks and how these tasks are coordinated with those of other participants.

This in turn avoids confusion, gives each participant a focus, an objective, and allows coordinators to measure progress made. The result is that time is used more efficiently, the resulting work is more complete and accomplished without the conflicts that confusion brings.

Both Pre-project Investigation and Planning are discussed in greater detail in Chapter 3.

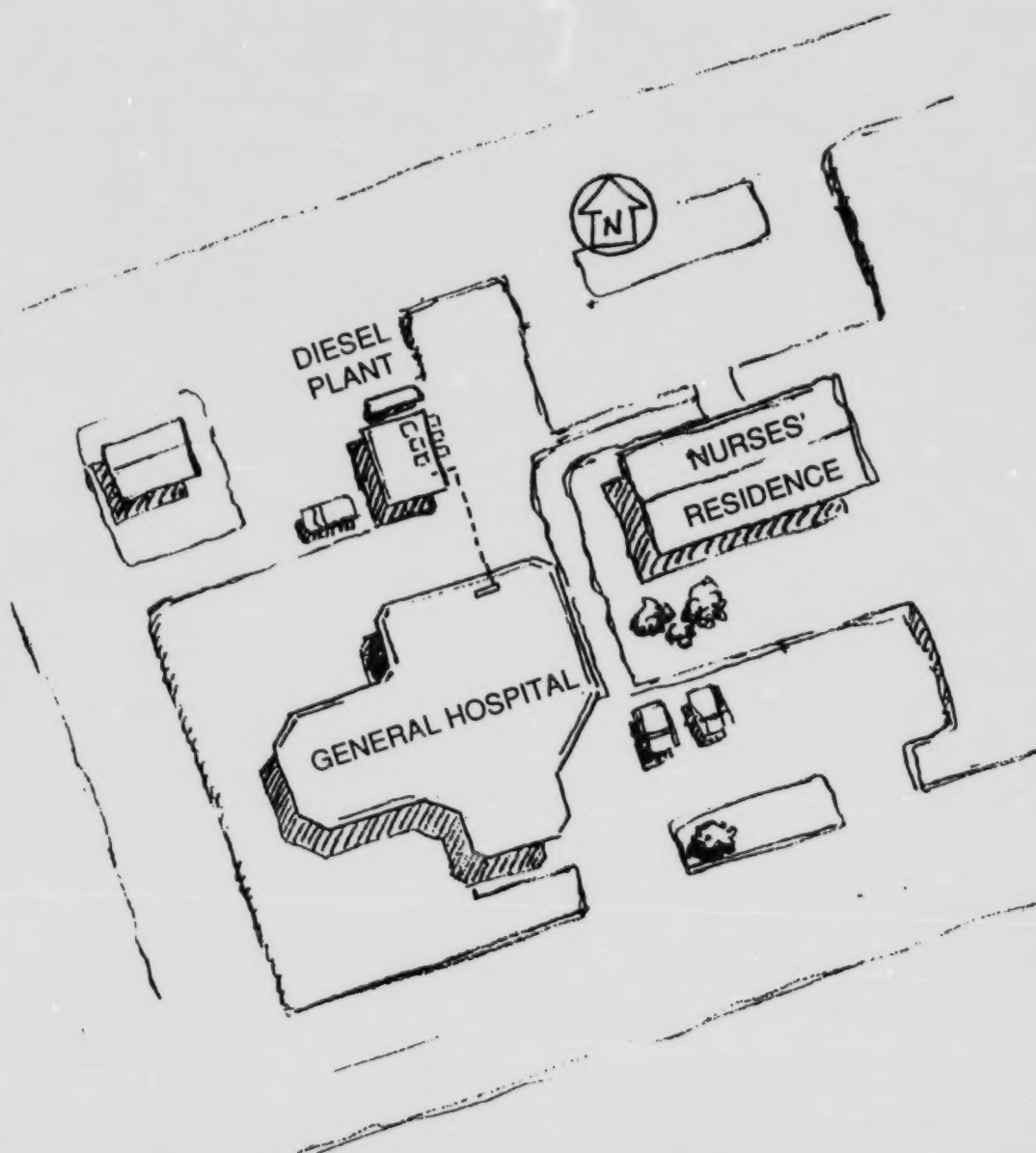
The following chapters are organized to provide information to facilitate WHR/D discussions. They are based on an existing WHR/D project described in Chapter 2.

Chapter topics include:

- management considerations;
- financing considerations;
- social and economic considerations;
- legal considerations; and
- technical considerations.

Waste Heat Recovery Installations

2



II. - WASTE HEAT RECOVERY INSTALLATIONS

Why do we look at installations done in other communities? There are several good reasons:

- it shows that WHR/D projects can be built, that the systems do work and that heat users do save money;
- it provides an idea of typical project costs;
- it gives an idea of the time it takes to go from talking about a system to having an installed working system;
- it shows who was involved in the project and gives names of people or organization participants can talk to or write to for more information, to ask questions as to how they managed their project;
- it lists the type of information that will be needed;
- it gives examples of how other projects were developed;
- it describes all parts of the project and who is involved in each part as an idea becomes a project and finally a working system.

A. - Case Study - Attawapiskat, Ontario

The community of Attawapiskat is located in Northern Ontario near James Bay. The people of Attawapiskat are mostly native (95%) and of the 427 residences, 200 residences have electrical service rated at 20 amperes. The largest electricity users in the community are the Ontario Ministry of Health and Social Services and the Band Council. The community's power requirements (220 kW average load) are served by four 175 kW diesels owned by Ontario Hydro. The majority of the private dwellings are heated with wood, with propane used for cooking and lighting. In many respects, Attawapiskat is representative of many of Canada's remote communities.



Figure 2.1

THE ATTAWAPISKAT HOSPITAL RECEIVES HEAT
FROM THE NEARBY DIESEL ELECTRIC PLANT
THROUGH DISTRIBUTION PIPES

The construction of the new James Bay Hospital in Attawapiskat offered an opportunity to use a waste heat recovery system to reduce the hospital's annual fuel usage. This system was successfully installed by Ontario Hydro in cooperation with the James Bay Hospital Board and the Ministry of Health, to serve the community's new 21 bed hospital.

1. - Pre-project Investigation

In 1982-83, the James Bay Hospital Board and Ontario Ministry of Health began reviewing plans to build new hospitals in several Northern Ontario remote communities. Together with their architects; Osburn Cotnam and Associates of Timmins, Ontario, they looked at several possible ways to save energy. They talked to Ontario Hydro which also looking into WHR and was willing to participate providing that the WHR/D system could pay for itself in five years.

The Energy Study and Development Department of Ontario Hydro reviewed the Attawapiskat plant's diesels, their condition, their age and the hospital's future power requirements. They recommended that one of the older 175 kW units be replaced with a larger diesel complete with WHR equipment. The Board agreed with the recommendation to use recovered heat for the hospital, providing the cost of the distribution system could be paid out of the heating oil savings in five years. The engineers for the hospital; Fodor Engineering in Toronto, Ontario, incorporated changes to use recovered heat in the hospital design. Ontario Hydro's new diesel with WHR equipment and the distribution system to the hospital were installed in 1984 by NWD Diesel Power Ltd. of Thunder Bay.

Heat User

The design of the new James Bay Hospital for Attawapiskat included four oil-fired hot water boilers to provide heating and domestic hot water. The hospital's space heating system included three ventilation units with hot water coils and several perimeter wall-fin radiators. The hospital design called for a 1858 m² (20 000 ft²) floor area with RSI 7.0 (R40) insulation throughout.

The heating system uses a water and glycol solution which is pumped from the boilers to the coils and radiators and then returned to the boilers. The boilers heat the solution to 82°C (180°F). After the solution gives up its heat to the hospital it is returned to the boilers at 71°C (160°F). The boilers are rated to provide a maximum of 432 kW (1 474 000 Btu/h)¹ of heat. Over one year the hospital would use 113 000 litres of heating oil (23740 Impgal) to provide a total of 847 000 kWh (3 231 164 000 Btu). The cost of heating oil in Attawapiskat in 1985 was 46.2¢/L. The cost to heat the hospital for a year was (113 000 x \$.462) \$52,200.

1

One litre of heating oil is equivalent to 11.137 kW (38 000 Btu).

The new hospital, which would be one of the largest users of electric power in the community, was located 20 m (approximately 65 ft) from the power plant. This location was selected to minimize the cost of the distribution system.

Other large heat users such as the Nun's residence, the nurses residence, and the Catholic diocese are all located within 35 metres of the power plant. When the WHR system is enlarged, or more new diesels added, these customers may also benefit from recovered heat.

WHR System Planning

As Attawapiskat was Ontario Hydro's first WHR project, considerable investigation and development were carried out to determine the best way to develop this and all subsequent Ontario Hydro WHR installations. The success of the Attawapiskat and subsequent projects shows that this attention to investigation and development has provided substantial benefits including a high degree of project organization and significant project cost reduction. Considerable planning, evaluation of alternatives and calculation of expected heat supply/demand was carried out to ensure the contracted heat could be delivered. Exhaust heat was considered at first but jacket heat offered more deliverable heat with less maintenance and less potential problems. As a result only the jacket heat recovery system was employed.

In developing the Heat Supply Agreement both the user and the supplier were careful not to set any pricing precedent which would jeopardize possible future projects such as heating the nearby nurses residence. Both wanted a practical agreement which would cover the systems costs yet be fair to any future users. Ontario Hydro could, in the future, install exhaust heat recovery or add new larger diesels to provide for additional heat users.

The major concerns of Ontario Hydro and the Hospital Board were the rate to be charged for the heat, possible changes in the price of oil and the quantity of heat available.

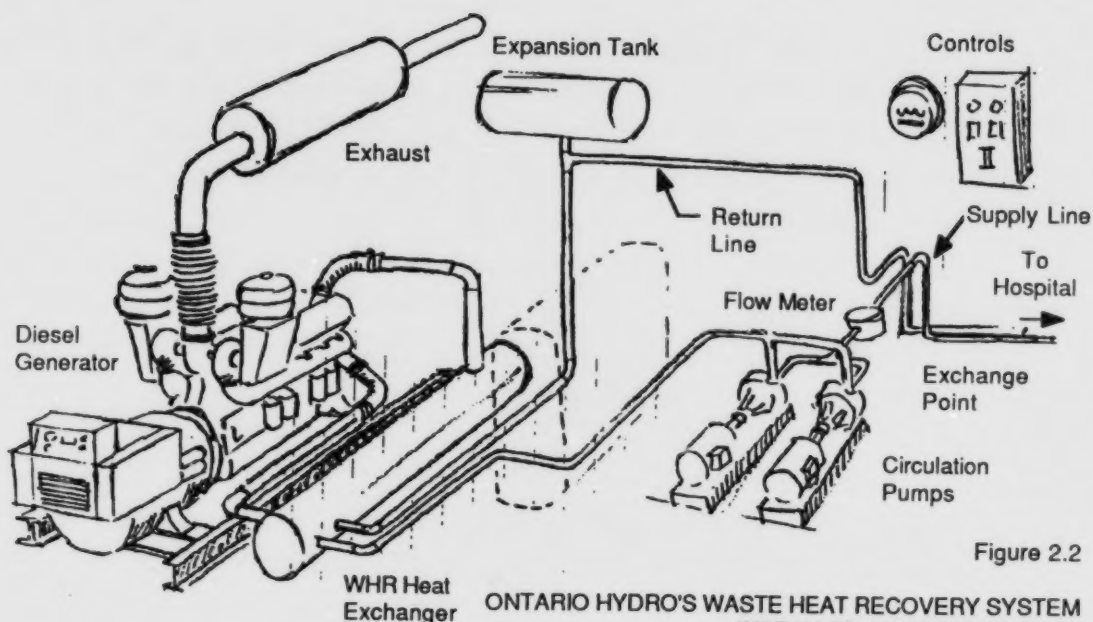
Both the Hospital Board and Ontario Hydro were concerned about the future price of oil as neither wished to be disadvantaged should the oil price rise or fall. Both agreed to tie the rate charged for the heat to the price of oil. This was accepted as fair since without the WHR system, any oil price changes would still have to be accommodated. The net savings were calculated to be 35% of the hospital's annual fuel bill. The agreement between the Board and Ontario Hydro guaranteed that the cost of the heat would always be 65% of the equivalent cost of heating oil.

To ensure the ability to deliver the specified heat, Ontario Hydro limited the guaranteed heat supply to 80% of the electricity production. Only 800 watts of heat could be sold for each kilowatt of power generated. At this rate the WHR system would supply 70% of the hospital's heat.

2. - Power System Design

The pre-project investigation showed that the WHR/D system would be very beneficial and that the payback requirements could be met. Ontario Hydro selected a Caterpillar 3412 DIT with factory installed WHR equipment. Later, the other three diesels were modified and included in the WHR system. The cost to install WHR equipment at the factory was 25% of the cost to modify the other diesels at Attawapiskat. This difference should be taken into account when planning whether to modify or replace a diesel.

Ontario Hydro's heat recovery system included an expansion tank, a heat recovery heat exchanger, two circulation pumps, a flow meter, a heat meter, controls for the pumps and a new outdoor fan, plus the associated piping and valves as shown in Figure 2.2. The outside plant wall was designated as the exchange point.



3. - The Distribution System

A pre-insulated 76.2 mm (3 in) RIC WIL carbon steel pipe was selected for the distribution system and installed 1.8 m (6 ft) below grade. Buried lines under a driveway separated the hospital and the power plant. Recirculation pumps cycled 50% water, 50% glycol solution between the hospital heat exchanger and the diesel plant recovery heat exchanger. At the hospital heat exchanger, the hospital heating water was raised to the required 85°C (185°F) for distribution throughout the hospital to provide the required heat.

4. - The Heat Path

The Attawapiskat Heat Recovery and Distribution System employs three closed loop fluid circuits as shown in Figure 2.3. In the first loop, engine coolant leaves the diesel at 96°C (205°F) and gives up a percentage of its heat to the heat recovery exchangers. The distribution solution picks up this heat from the recovery exchanger and brings it to the hospital exchanger at 85°C (185°F). The hospital

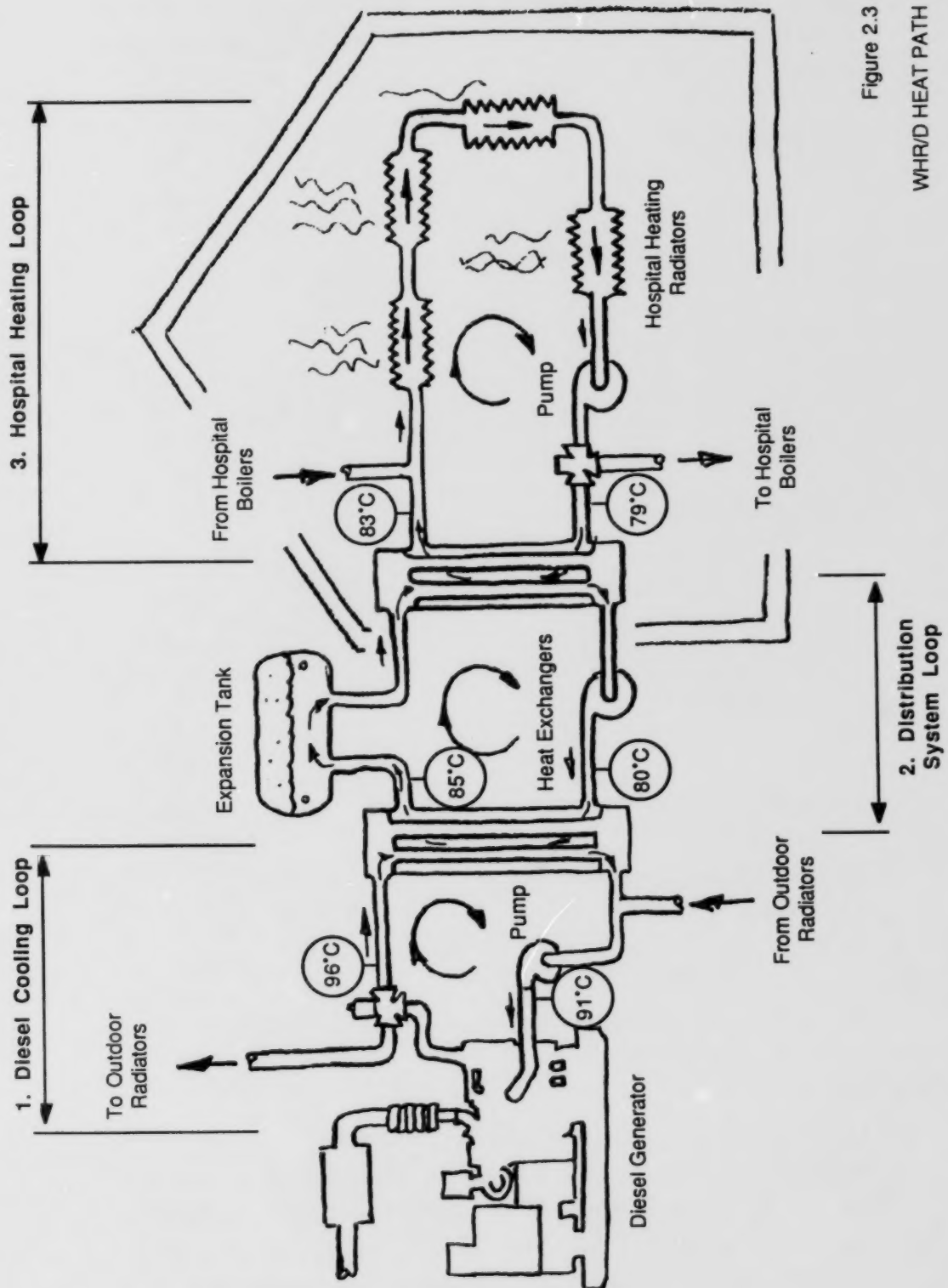


Figure 2.3

WHR/D HEAT PATH

heating system (the third loop) picks up this heat at the hospital exchanger and distributes it throughout the hospital to provide space heating.

5. - Project Cost

Both Ontario Hydro and the Hospital Board agreed to pay for their own respective parts of the installation.

Project Capital Costs

The capital cost to Ontario Hydro and the hospital were estimated as follows:

Supplier (Ontario Hydro)

Heat recovery system	\$18,000
Heat distribution system	\$21,500
Engineering (hospital)	\$20,000
Freight & Contingency	<u>\$14,900</u>
Total	\$74,400

Customer (James Bay Hospital)

Hospital's heating system modification	\$16,000
Engineering	<u>\$10,000</u>
Total	\$26,000

Project cost per kilowatt of heat delivered was \$427/kW based on an average 234 kW heat load.

Ontario Hydro's second project at Fort Albany had a project cost of \$250/kW. In this case, a completely new power plant was built adjacent to a new hospital and the WHR/D system was included in both from the start. This difference in cost between Attawapiskat and Fort Albany is important. Typically, the modification of an

existing installation in a community will cost 2 to 3 times more than incorporating a heat recovery system in the initial design of new buildings or new power plants. For this reason consideration should be given to a waste heat recovery/distribution system in the initial design stages.

6. - Project Economics

Since the Attawapiskat WHR/D system started operation in the summer of 1984, the hospital has saved an estimated \$96,000 in heating oil costs (1984-1987). Currently, the WHR/D system supplies 80% of the hospital's heat, the remainder is supplied by the hospital's boilers. Since 1984, fuel prices have increased slightly from \$0.46/L to \$0.52/L.

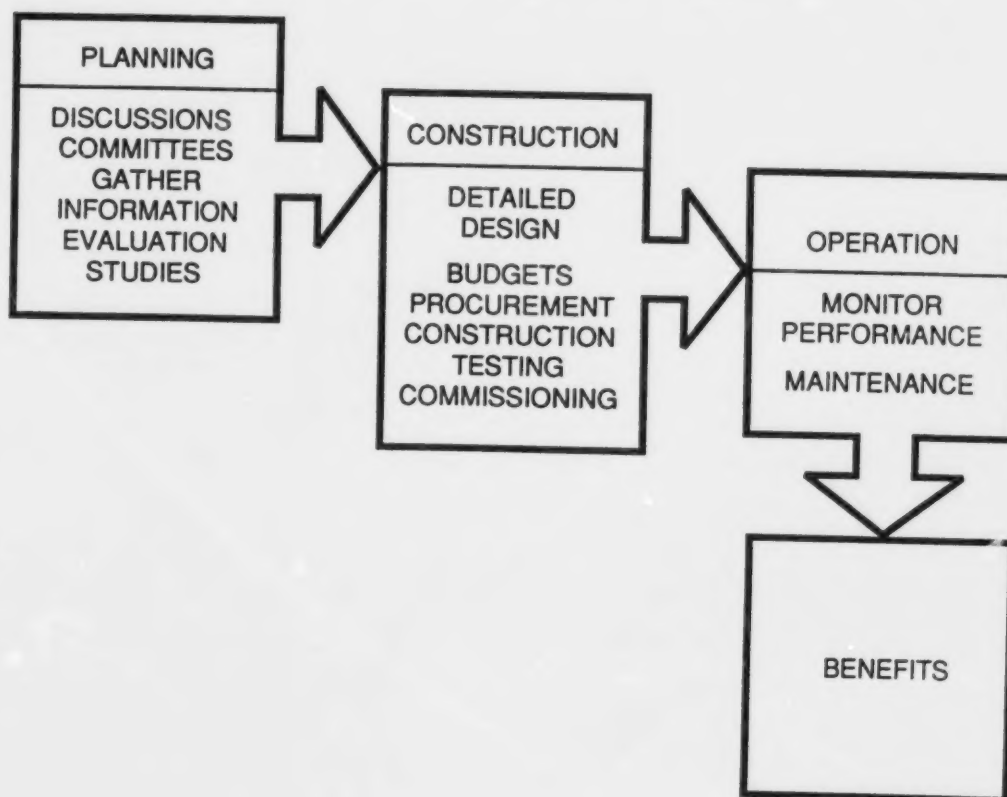
The hospital paid for the new system from fuel oil cost savings in less than two years, while Ontario Hydro paid for the recovery systems in less than three years. In the first year of operation the hospital saved \$14,554 in fuel oil cost while Ontario Hydro received \$27,030 in additional revenue from the sale of heat.

7. - Project Performance

System performance has been better than expected supplying 80% of the hospital's heating requirements. System start-up was relatively trouble free. The only serious problem encountered was air in the distribution lines. (Air reduces the ability of the system to transfer heat as it displaces the heat carrying fluid and acts as an insulator rather than a conductor.) The air problem decreased the delivery temperature to the hospital by 2°C (5°F). Once the air was purged from the system, the specified delivery temperature was attained.

Achieving Your Goal Step-by-Step

3



III. - ACHIEVING YOUR GOAL STEP-BY-STEP

The purpose of the following step-by-step example is to guide communities and government agencies through the usual course of events of a typical waste heat recovery project. Utilities may also find it useful. This approach is particularly useful as each step of the project can be described. We can talk about problems to avoid and hopefully save participants valuable time and resources. This will provide the framework for subsequent sections of this Manual.

A. - Guide to a Productive Supplier/Customer Discussion

Prior to holding meetings, concerns should be written down and discussed. Eliminate those concerns which are not valid and keep those which are major and important. Prepare an agenda, a list of things that are to be discussed. Limit this agenda to only important matters. Both the supplier and the user should give each other a copy of their agendas well before a meeting. Each should review the other's agenda and discuss the listed concerns. These concerns should be considered and answers prepared. In this way, both parties will be prepared to talk seriously about the proposed opportunity.

When the meetings between the supplier and user are held, the number of people at these meetings should be kept as small as possible. Only the people directly involved or those with valid concerns should be invited.

During the meeting, limit the discussion as much as possible to only those matters included in the agenda, and list any additional matters raised during the meeting. These concerns, if valid, should form part of the next meeting.

In this way, the discussions are controlled and limited to important issues. Limiting the discussion to the important issues will result in more productive meetings.

B. - Step-by-Step Process

The following are steps that should be taken for a typical project. These cover the planning, construction and operating phases. The first step is when someone within the community recognizes that an opportunity exists to save money by using heat from the community's diesel generators.

1. - Planning Phase

- Step 1 Recognize a WHR opportunity (see the questionnaire in Appendix E).
- Step 2 Discuss the opportunity with those most likely to be involved, particularly the power utility and those who would be the largest community heat users.
- Step 3 Form a committee with an appointed leader, preferably the heat supplier's or heat user's representative. Decide which duties, tasks are required and delegate responsibility to carry these tasks out. In many cases, the supplier will be willing to act as the committee leader.
- Step 4 Gather information regarding energy use and costs (Pre-Project Investigation). The user will need to provide such information as:
- a listing of the interests and concerns of the heat supplier and user;
 - a listing of any additional problems that may stand in the way of the project;
 - a layout plan showing the location of the diesel plant and each large building to be heated as well as any obstacles in between. This is helpful to determine the routing of the heat distribution lines (see Figure 3.1);

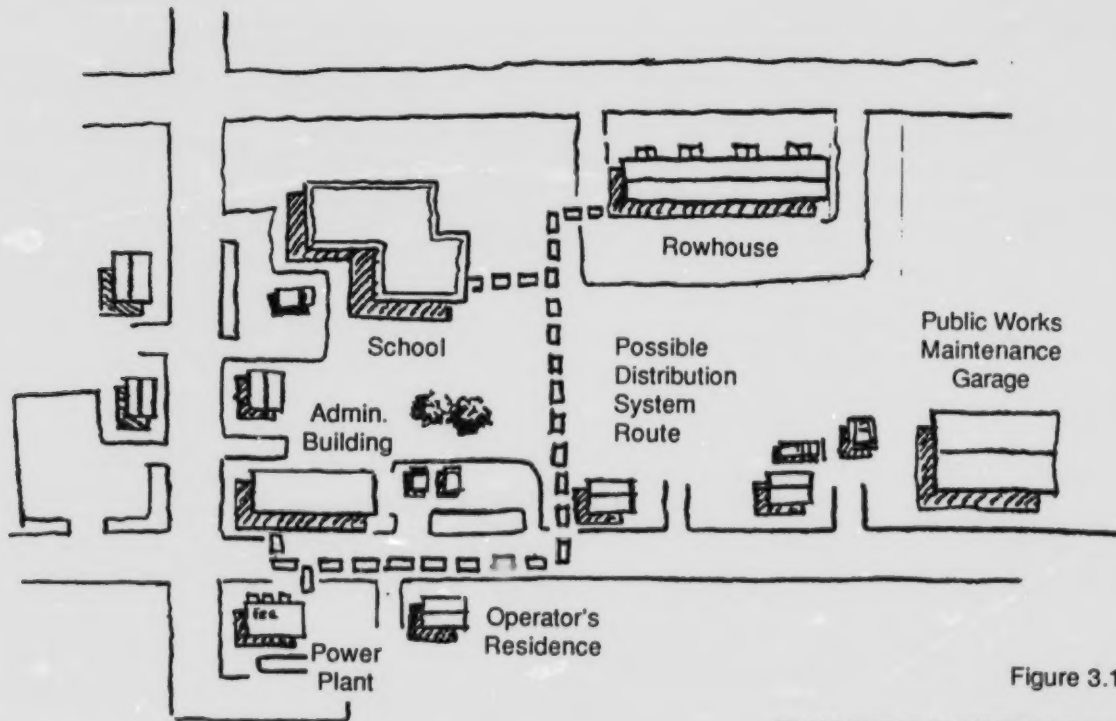


Figure 3.1

PLANNING THE DISTRIBUTION SYSTEM ROUTE

- the cost and amount of heating oil for the larger buildings or services in the community that will form the heating load for the heat supply system;
- the growth rate of the community as more people will require additional building space and services which could use recovered heat;
- a plan of how the community would like to develop showing any proposed future new buildings, changes in roadways, water and sewer systems. Knowing when and where future developments will occur may save considerable contract costs by doing similar work together. For example, if the community plans to put in buried waterlines, the distribution system could be laid

along side in the same trench. This would provide the additional benefit of freeze protection for the water lines while at the same time spread the excavation costs over two projects.

Typically, the supplier will need to provide information about the diesel electric production including:

- total quantity of kilowatt-hours produced each month;
- peak and minimum electrical demand levels;
- a good appreciation of how the electrical output varies during each day of the week. This does not have to be exact but should give the peaks and the low load periods;
- the age, type and size of diesel engines in use;
- future plans regarding replacement of diesels, upgrading of equipment, installation of larger diesel sets to meet increasing loads and locations;
- policies to which the supplier must adhere in providing electric power;
- equipment costs;
- listing of experts in the WHR field.

Step 5 Discuss as a committee the information collected particularly:

- any planned community changes such as new buildings, changes to the power plant, new roads, new public services;
- types of systems used in other communities;

- the type of system suitable for the communities particular needs;
- the cost and benefit of the proposed system;
- heat supply agreements used in other communities;
- financing alternatives;
- the concerns of the supplier and the user of the heat, project costs, schedules, reliability, maintenance and logistics;
- approvals required for the project.

Step 6 Prepare an in-committee evaluation based on the collected data and the general design proposed. This evaluation should include:

- a cost estimate;
- a map showing the source of the heat and the buildings to which the heat will be supplied;
- an estimate of the amount and cost of fuel that will be saved using the system;
- a draft of the proposed heat supply agreement.

Step 7 Based on the committee's evaluation, arrange for a feasibility study. Feasibility studies are discussed further in Section 7.1. In many cases the electric utility will provide the complete study. Where a third party consultant is required, a request for quotation to perform a study is prepared and sent to consultants, preferably those who have participated in previous WHR projects. The proposals received are evaluated and the study awarded to the most qualified consultant. The completed

study should contain a feasibility assessment of the most promising WHR/D options, a cost estimate as well as a preliminary design of the recommended system.

The study results should, at this stage, be compared with other possible energy conservation measures for both the diesel and buildings. Such measures may be more cost-effective than WHR/D although they are not usually exclusive.

- Step 8 Upon completion of the feasibility study the committee reviews the study findings. This is an opportunity to discuss how the project should be developed as well as lessons learned from previous projects in other communities.
- Step 9 If the study shows that a WHR/D system would make good economic and financial sense, the committee can decide to proceed with the project. A formal heat supply agreement is entered into and financing arranged.

2. - Construction Phase

- Step 10 While the supplier will most likely use its own technical staff to design the WHR part of the system, the customer may elect to hire his own consultant to design and build the distribution system. In this case the customer prepares a request for detailed design, project management and construction management services. This request includes requirements covering
- a detailed design,
 - equipment specification,
 - a project budget,
 - a project schedule, and

- performance specification.

This request is issued to selected engineering consultants who have demonstrated capability in:

- working in remote areas;
- experience with previous WHR systems;
- having adequate financial strength, equipment and trained personnel to cover the following areas:

Mechanical piping, heat exchangers, valves, pumps, tanks and insulation;

Electrical installations controls and computer based logic controllers;

Civil equipment, foundations, supports and structures.

The proposals received from invited consultants are reviewed and the committee selects the most qualified consultant. Regardless of who performs the design, a full site survey is required.

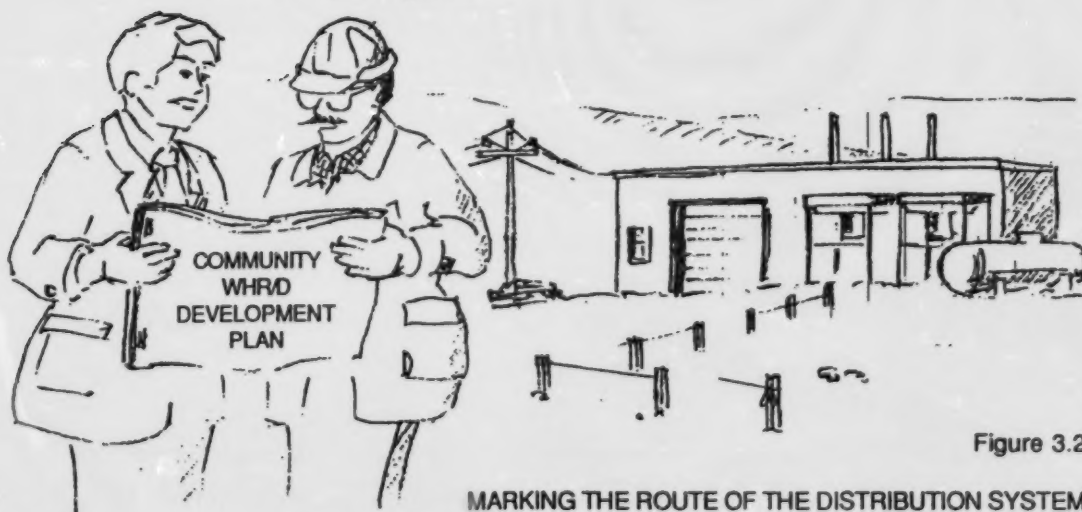


Figure 3.2

MARKING THE ROUTE OF THE DISTRIBUTION SYSTEM

After measurements and the proposed routing are established, a detailed design can be developed. From this detailed design (which incorporates the selected equipment), a comprehensive material and equipment listing can be tabulated. The equipment and material cost, in conjunction with the estimates for labour and construction, form the project budget. The detail design and project budget should, at this stage, be presented to the committee for a decision whether to proceed or not. Since the system will be defined in detail, the budget developed at this stage will reflect closely the actual project cost.

- Step 11 With the committee's approval, equipment and installation specifications can be developed and requests for quotations issued.
- Step 12 When the corresponding bids are received, these are compared with the project budget. If the costs are in line, the committee can take the decision to proceed by awarding the contracts to the selected bidders.
- Step 13 Apply appropriate inspection and expediting to ensure that all required equipment and material is indeed the material ordered and that equipment functions properly before it is shipped to the community. In previous cases, the supplier has performed inspection and expediting functions on behalf of the user.
- Step 14 Receive the material and equipment at site, check it against the material/equipment list, and supervise it so it does not mysteriously disappear. Supervise construction in a manner required to ensure the project is completed correctly and expeditiously.
- Step 15 Test and commission the equipment and systems; record the performance of all equipment and retain these records.

Compare the performance attained against the specified performance.

3. - Operational Phase

Step 16 Monitor the performance of the system on a weekly basis recording the temperature and flow. Deterioration of either temperature or flow may indicate that some part of the system requires maintenance.

In our Attawapiskat example, the architect evaluated several ways to reduce the heating costs of the new hospital. While investigating ways to conserve energy in the design of the building he contacted EMR. In turn, EMR recommended discussing with Ontario Hydro the use of the waste heat (Step 2).

A committee was formed of the heat supplier Ontario Hydro, the hospital board and the project architect, Andy Cotnam (Step 3). The supplier's representative who was appointed as chairman of the committee, collected pre-project investigation information (Step 4).

During the pre-project investigation, the committee obtained from other provincial utilities and government agencies, in particular EMR, similar case studies of their heat recovery projects. Using cost figures from the case studies and information from equipment suppliers, the cost of the system was estimated to be about \$100,000, \$75,000 for the supplier's part of the system and \$25,000 for the user's part (Steps 5 and 6).

Ontario Hydro supplied the feasibility study for the proposed project (Step 7). Since the study indicated that a WHR/D system had potential, the committee discussed the price of the heat and agreed to proceed with the installation (Steps 8 and 9).

With financing in place, the remainder of the Attawapiskat project (Steps 10 through 15) proceeded with a minimum of difficulty due largely to the selection of a qualified engineering firm and an experienced, well equipped and organized engineering contractor.

From 1983, when heating with recovered waste heat was first considered, it had taken two years to discuss, negotiate, design, build and start operation of the WHR/D system.

Project Management Considerations

4



WHR/D COMMITTEE

IV. - PROJECT MANAGEMENT CONSIDERATIONS

This chapter deals with questions of permission, agreements, ownership, organization, roles and responsibility with respect to the community, the community's representatives, the electric utilities, Federal and Provincial or Territorial Governments, contractors, equipment suppliers and engineering consultants. The activity that brings these groups together in a WHR/D project is the Project Management Process.

A. - Overview of the Project Management Process

The step-by-step process, outlined in Chapter 3, provides a general guide of what to do. This chapter describes the various roles that participants have in Project Management. It is intended to overcome two major roadblocks in building a project; lack of communication and lack of cooperation. These require that all concerned be involved in discussions regarding WHR/D from the start, that their concerns be heard and their questions answered.

Participants who wish to start a WHR/D project should consider that an organized professional approach will give greater benefits. A request for action of any kind must be accompanied by a good reason for organizations to act. Such good reasons to act include conservation of non-renewable resources, reduction in the costs to provide services or increased efficiency in delivering services, that is, more services, for the same money. The approach taken is just as important. Most organizations are agreeable to a valid request providing their jurisdiction and purpose is understood and respected. To ask for their cooperation in developing a WHR/D project, participants should talk to or write to them explaining the community's desires and intentions. For example, a community representative should contact

- the owner of the generating equipment,

- the operator of the generating equipment,
- the organizations or agencies who pay for the power produced or are subsidizing the purchase of the power.

Some utilities have adopted a policy of including WHR equipment on all new or replacement diesel units for future applications.

Each province or territory provide services in a slightly different manner. The information in the Appendices can help the committee find the right people to talk to. (It is important to note that the responsibility for on-reserve power generation is currently being transferred from the Federal Government to the Provincial utilities.)

The Project Management Process also involves obtaining permission and funding from appropriate sources as well as controlling the project effort, so that project goals can be attained.

B. - Regulatory Requirements

The supplier of electric power in any jurisdiction is governed by regulations to protect the public, the electric power supplier and the environment. This may or may not allow the provision of distribution heating. The utility may be required to apply for an extension to its charter to provide heating. Ontario Hydro is the first utility to do so.

Agreements between the electric supplier and the customer with regard to liability for payment, subsidies, or provision for payment in default may have to be amended to cover the sale of heat as well as electric power. Revenues from the supply of heat may give rise to a restructuring of subsidy arrangements.

The supplier may be reluctant to sell heat as it may become defined as an essential service requiring the supplier to provide heat even when electrical production is interrupted. Most suppliers, however, are very interested in providing heat under a fair heat supply agreement.

C. - Setting Goals

The goal of installing a WHR/D system can be viewed as a progression of smaller goals, the sum of which will result in the completion of a functional project. Dividing large tasks or goals into several smaller well-defined tasks or goals is a well-known and frequently used project management method. When a large, complex goal is divided into smaller better defined tasks, people have a better understanding of the work to be done and the work, in turn, becomes more manageable.

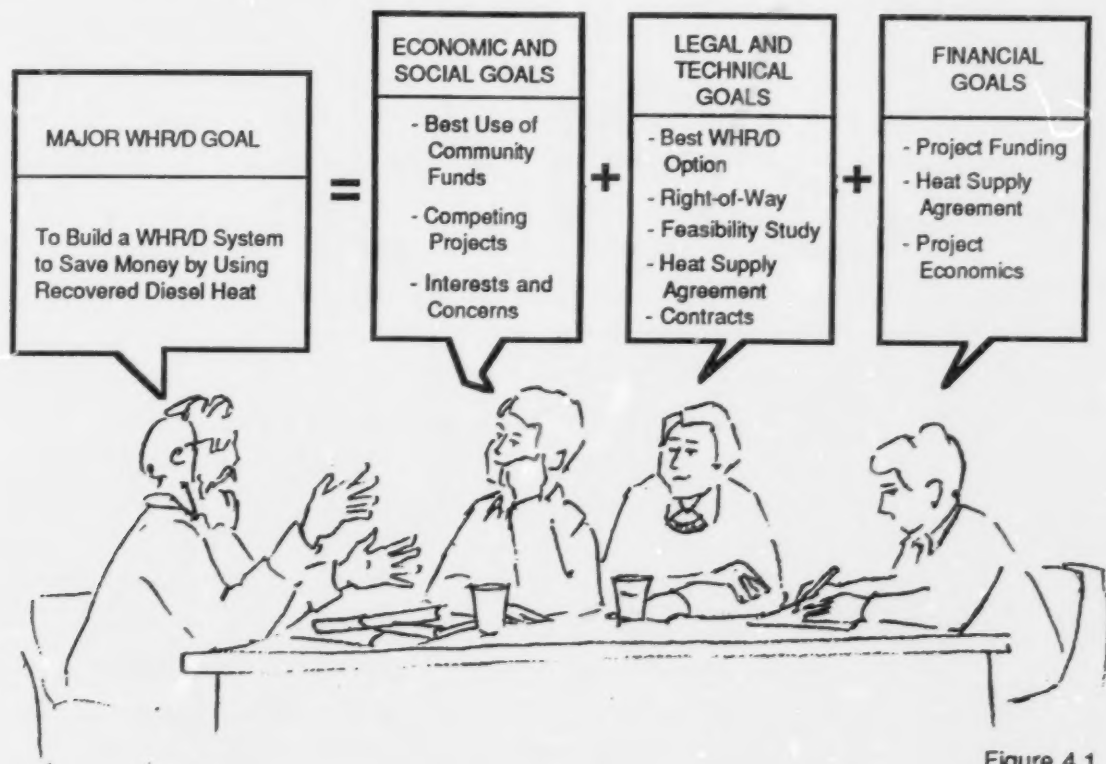


Figure 4.1

SMALLER GOALS ADD UP TO THE MAJOR GOAL

In a WHR/D project, the major goal is to save heating oil costs by recovering waste heat and using it in a beneficial manner. The smaller goals are those listed in the step-by-step process. Each step represents a goal, another step towards achieving the major goal or objective.

D. - Getting Organized

Achieving each of these goals requires commitment of people within organizations to fulfill certain roles. The major roles in a WHR/D project include the following:

**The Project
Manager:**

A person capable of defining the major goal, dividing it into smaller goals or tasks with duties and responsibilities, finding and motivating people to perform these tasks, monitoring the progress of these people and guiding them past impediments to achieve what is now their goal. In many previous cases, the supplier has provided the project manager and necessary technical support. In some WHR/D projects there are two project managers, one acting for the supplier to look after the heat recovery, and one acting for the user to look after the heat distribution and end use equipment.

**The Project
Secretary:**

A responsible person whose duties include recording the decisions taken by the committee, gathering the information into one convenient location, preparing communications (letters, memos, the draft agreement document) receiving information from the organizations with which the committee must negotiate, and distributing information to the committee members.

The Committee
Members:

To assist in achieving project goals, the following capabilities and representation may be required:

- for legal considerations,
- for contractual and money considerations,
- for regulatory and government considerations,
- for technical and technical contractual considerations,
- to keep the community informed of the project intent and progress.

In forming a committee it is advisable to keep the number of persons on the committee as few as possible. This is not meant to deny others information, but coordinating a smaller team is easier than a larger group.

E. - Sharing the Work-Division of Responsibilities

As indicated in the Example Agreement (Appendix B), each participant will be responsible for an agreed and defined part of the work required to complete the project. Responsibility should be assigned accordingly as one party cannot be responsible for work outside his respective part of the system. There is, however, considerable work which is common to both, particularly in the initial stages of a project. This covers items such as drafting the Agreement, seeking funding, obtaining approvals and keeping the participants informed of each other's progress.

This initial work requires close cooperation and communication. The volume of work must be balanced against the need to maintain a manageable committee size. This may require that some of the work

will have to be done by consultants and/or task groups who will receive direction from and report to the project committee. In some cases committee members will readily volunteer, in others the project manager's encouragement may be required to gain the support and commitment required.

Some of the interests and concerns regarding how work is divided and shared on previous projects are as follows:

- The heat supplier is primarily interested in electricity and heat. The supplier's concerns stem from overly lengthy and unproductive discussions because problems not related to heat supply are introduced. As well, some participants do not show up at meetings even when they are arranged well in advance. Likewise, project work which the user's representative agreed to undertake, is left undone. These problems slow progress and make productive discussions difficult.

- The heat user, on the other hand is concerned about the lack of information and experience in WHR/D systems among the community's representatives. Not knowing what information to gather, how to present information and the implication or significance of some information is a concern. Participating in a WHR/D project for the first time may involve considerable learning.

F. - Guarantees

The performance guarantees of project participants are discussed in the Agreement (Appendix B). This section deals with guarantees for third party services, material and equipment.

Guarantees regarding material and equipment present a different problem. Manufacturers guarantee their equipment or materials for a fixed period of time and will repair any deficiency on their part providing the equipment is shipped back to their factory. This does little to help a community who must go without recovered heat or the utility who must forego revenues until the equipment is returned and reinstalled.

The best assurance is to inspect and functionally test, whenever possible, the equipment at the manufacturers before it is shipped. However, this may be difficult if not impossible to do in this case. Where possible, the installation contractor should be made responsible for ensuring the equipment operates as specified.

Many remote communities do not have the capability or resources to fix manufacturing errors at site. In most previous projects, the utility, who normally has more experience with manufacturers, has managed the equipment procurement on behalf of the committee.

One further requirement in purchasing services, material or equipment is the requirement for adequate liability insurance and performance guarantees. Equipment should be supplied with written guarantees stating the specified performance and the performance of the equipment if and when tested. The manufacturer must also supply equipment maintenance manuals describing how to keep the equipment in proper working order. The installation contract should also include provisions for "as-built" drawings.

With proper installation, inspection, operation and maintenance, satisfactory performance is usually experienced.

G. - Deciding Which WHR/D Option to Install

Since there may be several ways to install a WHR/D system, the information available on similar projects may result in a variety of implementation options. Each option may vary in:

- equipment prices,
- amount of heat to be used,
- periods when heat is available,
- type of recovery system to be used,
- type of heat distribution system to be used,
- different applications for the heat.

In guiding the decision of which option to select, the following aspects must be considered:

- the minimum and maximum quantity of heat that can be reliably generated continuously;
- the concerns of all participants about the reliability and availability of the generated heat;
- project funding;
- payback period;
- the cost versus benefit trade-off. The evaluation of this trade-off may involve:
 - a financial analysis where the cost of the project is compared with the money saved or revenue generated;
 - an economic analysis where the cost to the community is compared to the benefit;
 - a social economic analysis where the overall benefit is compared to the cost.

H. - Dealing with Consultants and Contractors and Other Third Parties

A Third Party is someone other than the heat supplier or the heat user. Examples of third parties are consultants, contractors and equipment suppliers. When dealing with third parties, the project participants can avoid unnecessary difficulty and possible project failure by considering the following:

- (a) The typical heat supplier who has both technical and commercial capability often deals with third parties to purchase equipment and services. Consequently, the supplier often looks after all project equipment purchases and selection of contractors on the user's behalf.

This has several benefits in that it reduces the number of contractors the committee must deal with, improves co-ordination and management of project work and saves time and money by 'batching' project work.

(b) Information regarding the community project must be gathered together and be made available in one convenient place. This will save considerable cost and time in dealing with and describing the selected system to a third party.

(c) Ensure that the project requirements are clearly defined and understood before the contract is awarded by meeting with the contractor to review each requirement.

(d) Ensure the work is carefully planned before construction starts by requiring the contractor to submit a plan and schedule covering the contracted work. Each hour of planning and investigation saves approximately four hours of resolving difficulties.

(e) Minimize changes to the system after the contract is awarded by requiring the contractor submit all proposed changes for approval to the committee's representative. Specify that any unapproved changes will not be paid for and those changes which reduced system performance will be corrected at the contractor's expense.

(f) Monitor the contractor's performance. Have either the supplier's or the user's representative look at the amount of work done and discuss with the contractor his progress compared with the contract and schedule.

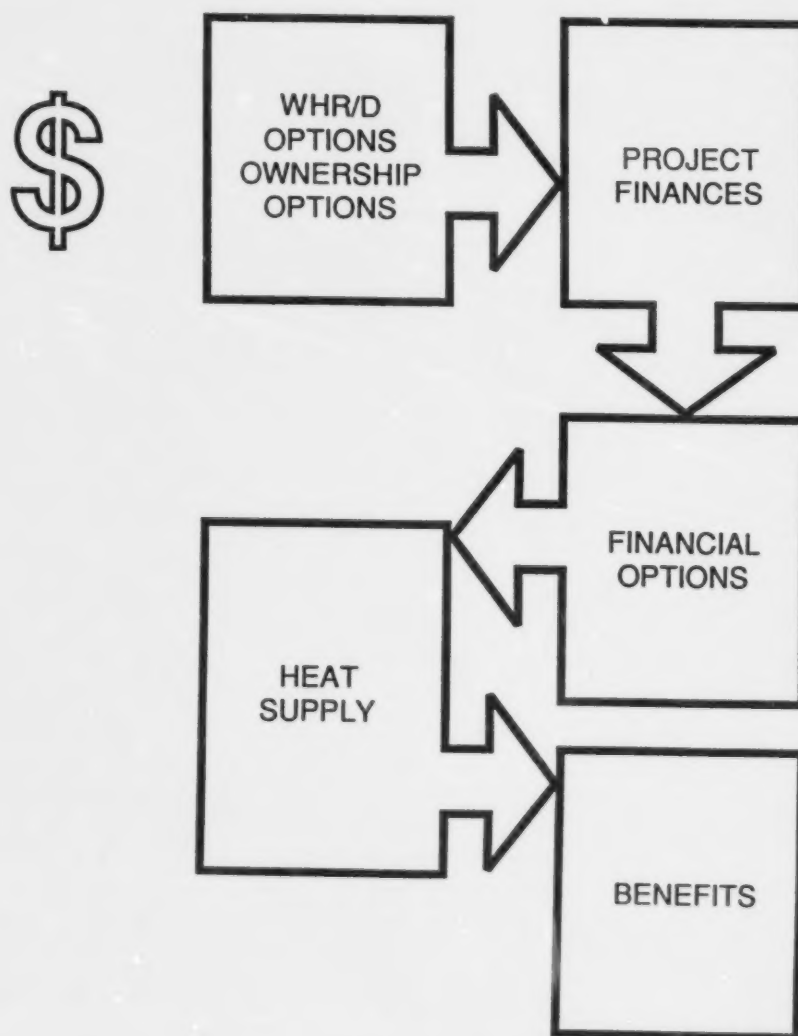
(g) Protect the contractor and contract personnel from unnecessary outside interference while the contractor is engaged in completing the work.

(h) Have the contractor's work inspected by the engineer/expert responsible for the design of the system before completion of the project.

- (i) Ensure the system operates as specified before the contractor leaves the community or final payment to the contractor is issued, by witnessing the system start-ups and by comparing the operating temperatures with the specified temperatures.
- (j) Ensure the contractor provides training for the community's operators in the operation and maintenance of the equipment. The operator should participate in the commissioning and start-up of the system.
- (k) Arrange for an agreement with the contractor to provide the community operators with help or instructions to resolve difficulties with the system.
- (l) The person and position to which the third party must report should be specified such that the control of information, requests, and approvals to or from the third party can be properly maintained.
- (m) 'Turnkey' contracts are not recommended as the turnkey contractor is only responsible for installing a WHR/D system for a specified price. When the installation is complete, the community is left without assistance to figure out the operation of the system. Contracts for consultant or contractor services must include provisions for operator training and assistance during the first year of operation.
- (n) In selecting a third party, select only those with proven experience, capable personnel and the equipment necessary to operate in remote areas. Before signing any third party contract, contact at least three organizations which the third party in question has listed as past clients and request an assessment of the third party's performance on their particular projects.

5

Financial Considerations





V. - FINANCIAL CONSIDERATIONS

How the WHR/D system is paid for depends on the Recovered Heat Supply Agreement, a formal agreement between the supplier and user.

In general, utilities make no profit from operations in remote communities. In the user's case, raising money for projects is a problem. Limited annual funding means not having enough money to cover all the community needs. Several projects or community needs will compete for the same allocation dollar. How should communities make decisions as to which project is more beneficial and therefore selected?

Chapters 5 and 6 are intended to help with this decision-making process.

A. - Project Financial Benefits

Every cost has a benefit, even the cost of heating oil has the benefit of warmth and comfort. If the same heat can be provided for less cost, the benefit from the use of the money is greater. A WHR/D installation will provide the same heat for less cost.

At Attawapiskat, the use of a WHR/D system reduced the yearly heating cost from \$52,000 to \$37,446, saving \$14,554.

The WHR/D system installed at Lac La Martre provides 99% of the heat required for a school saving \$26,485 in heating costs each year (reference Appendix D).

The owner of the Snowshoe Inn in Fort Providence, NWT, installed his own diesels with waste heat recovery. He invested \$256,000 and cut his heating and electricity costs from \$188,000 to \$59,678 a year (reference Appendix D).

At Fort Albany, the Ministry of Health and Ontario Hydro took advantage of WHR/D when the new hospital was constructed. Ontario Hydro required a new power plant. This new plant was built adjoining the hospital and supplies 90% of the required heat using a WHR/D system (reference Appendix D). The \$50,000 annual heating costs were reduced to \$38,000.

The financial benefits to the customer in most WHR/D cases is a 25% to 50% reduction in annual heating costs.

The financial benefits to supplier can be the revenue from the sale of heat which in turn reduces the cost of operating in the remote community.

B. - Project Finances

Cost-sharing project participants are concerned with finances but for different reasons during the three stages of a project.

During the first stage (pre-project investigation, planning and evaluation), participants are concerned with determining the project cost, deciding whether or not a WHR/D project is the best use of funds compared with other needs and deciding where and how to raise the required money. This first stage covers Steps 1 through 9 in our Step-by-Step Process in Chapter 3.

During the second stage, while the system is being constructed, the participants are concerned with controlling the cost of the project and ensuring that the money assigned to the project is not used for other purposes. The second stage includes Steps 10 through 14 in our Step-by-Step Process outlined in Chapter 3.

In the third stage, when the WHR/D system is operating, participants are concerned about the cost of the heat, the reliability of the heat supply and the cost of operating and maintaining both the recovery and distribution systems. This third stage covers Steps 15 and 16 of the Step-by-Step Process.

Financial considerations cover all of these steps because the participants will want to know expected costs in advance as work progresses from an idea to a working installation. The cost of the WHR/D system should be known before any money is committed to the project. Both the supplier and customer will want to compare the benefits of a WHR/D system with the benefits from other competing projects requiring the same money. In this section we look at how projects are compared financially.

When a project is evaluated financially, the cost of the project is evaluated against the future savings or earnings from the operation of the system. The cost is the funds spent to build the installation. The benefit is the earnings or savings that come in the years when the installation is operational. Because of inflation and interest rates money has a time-value, and earnings or savings expected in future years should be discounted to present value for comparison with present costs.

When participants have the project evaluated by either the utility or a financial consultant, they are interested in the cost of the project, the money discount rate, the savings or earnings the installation will bring each year during its life.

Each of these is briefly explained as follows:

Costs

As shown in Figure 5.1, various costs are incurred during the three stages of a project.

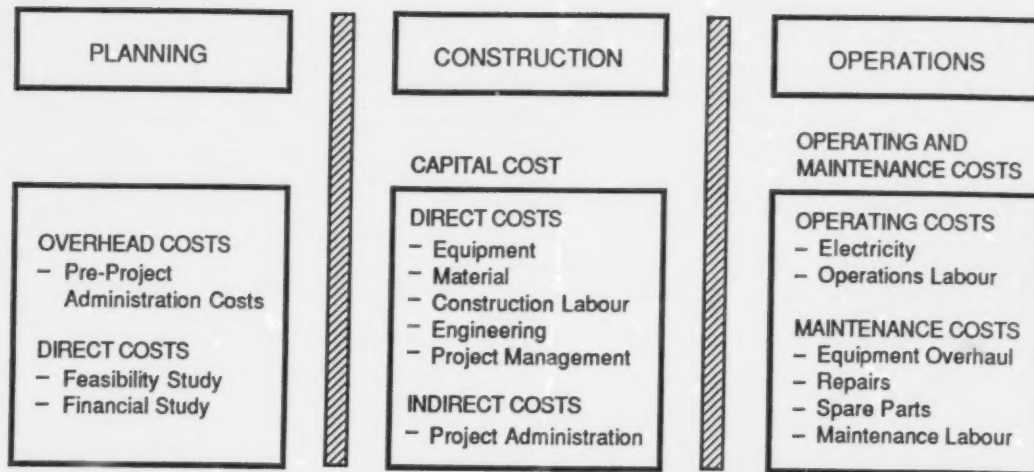


Figure 5.1

COSTS ASSOCIATED WITH PLANNING, CONSTRUCTION AND OPERATION OF A WHR/D SYSTEM

These costs can be divided into two groups:

- Capital Costs,
- Operating and Maintenance Costs.

Capital Costs include the following direct and indirect costs for each project stage mentioned.

a. Direct Costs

Planning Stage - engineering and financial study costs.

Construction Stage - equipment
 - materials
 - labour
 - engineering

- changes to buildings to put in the WHR/D system
- freight
- project management.

b. Indirect Costs

As the WHR/D project may be one of many concurrent projects, some services may be shared across all projects; services such as secretarial, postage, telephone, electricity and heat for the office space used for the projects. These costs are normally small and a respective portion of these costs are assigned to each project as an indirect cost.

Operating and Maintenance Costs

Both the supplier and the user may have operating costs associated with the operation of a WHR/D system. These can be separated into fixed and variable costs. Normally, operations and maintenance costs are fixed costs and the cost of recovered heat is the variable cost.

Generally, fixed costs include:

- the electric power or energy used by the WHR/D equipment such as the recirculation pumps;
- additional operating or maintenance costs to provide for personnel to look after and fix the equipment when repairs are required;
- maintenance and supplies to replace worn parts when required or to provide testing, lubrication or cleaning of equipment when required.

For a project to be financially worthwhile to participants, the fixed and variable costs must not exceed the annual savings, for it is out of these savings that the project is paid for. The fixed costs are a result of the investment in the project and the cost of operating the system. These will remain fairly constant as any loans are being

repaid. Other fixed costs, such as the operators' salary and costs for parts and supplies for maintenance, may need small annual adjustments. Variable costs will vary with the amount of heat used and the rate charged for the heat.

Savings or Earnings

Savings are the avoided cost of fuel oil minus the operating and maintenance costs. Earnings are the rates received by the supplier for the heat.

Discount Rate

To compare current costs with future benefits a discount rate is used. This discount rate varies with inflation and the cost of borrowing money. Governments or the supplier can provide users with discount rate information. Typically, the discount rate is 1% more than the prime commercial lending rate.

Life of the Installation

As even well maintained equipment wears out, a financial analysis assigns a life in years to an installation. A typical life of a WHR installation is 10 to 20 years while the typical life of a distribution system is 20 to 40 years. During these years of life the benefits from the cost are realized.

C. - Financial Analysis

When the Capital Cost, the Operating and Maintenance Cost, the Annual Savings or Earnings, the Discount Rate, and the Life are known, an analysis can be performed to determine the Net Present Value (NPV), the Internal Rate of Return (IRR), and the Simple Payback Period. These are important indicators for making decisions as to how project funding should be spent. Utilities usually have their own analysis models. Heat users without financial analysis expertise can employ the services of a financial consultant.

Net Present Value

The net present value (NPV) of an installation compares the anticipated savings or earnings with its cost. For each year, costs are subtracted from savings to obtain the annual net cash flow. The sum of the discounted net cash flow is the net present value of the project. If this value is positive, the benefits will outweigh the costs. Accordingly, only project installations with a positive (or in some cases zero) net present value are worth developing.

Internal Rate of Return

By regarding the project cost as an investment, the internal rate of return determines the percent payback on the investment. Where borrowed money is used, the project, internal rate of return should be greater than the interest rate for borrowing money. If two or more projects are being compared, the project with the higher rate of return should be considered. This technique should only be used by those experiences in the interpretation and application of the IRR analysis.

Simple Payback Period

Users are interested to know how many years of operation are required for the savings to repay the cost of the installation. A quick (but only approximate) method is to divide the capital cost by the net annual savings (savings less the operations and maintenance costs) to get the simple payback period.

Capital Cost Allowance

Under current tax law, when a new installation is purchased and installed, a tax deduction from income is allowed. For energy conserving installation, a Class 34 deduction is permitted where 25% of the capital cost can be deducted from income for the first year of operation. The remaining allowance may be deducted in the second and third years at a rate of 50% and 25% respectively. These tax deductions are important to both the customer and the supplier's cash

flow from the operation of the WHR installation in the first three years.

Contingency Allowances

Contingency allowances are the provisions made in the project cost estimate for the WHR/D to cover unforeseen problems, shortages, delays and accidental damage. If the utility, contractor or community have not had experience in installing projects of this nature, the contingency should be increased from the normal 10% to a higher percent (say, 30% to 40%). This will account for people learning how to participate in a project for the first time. Contingency allowances should only be considered at the costing level as they do not form part of the financial analysis.

Debt Service

The repayment of a loan is an operating expense and is not included in the financial analysis. The user, in most cases, repays both the principal and the interest on the money borrowed to put the WHR/D system in place. The monthly repayment should be taken into account when determining the rate structure if the heat is to be sold.

D. - Ownership Options

There are various ownership options available to remote communities in developing an WHR/D installation. These are some of the more common situations.

User Owned Installation

The user pays for both the recovery and distribution systems. In a user owned and operated system, the heat is supplied free of charge and the user pays the supplier for any maintenance or operator time required for the recovery equipment.

User/Supplier Split Ownership

In this Split Ownership case the supplier pays for the recovery system and the user pays for the distribution system. The user pays the supplier an agreed rate for the heat delivered. Each is responsible for the operation and maintenance of their respective systems.

Third Party Owned Installation (Investor Owned)

A third party who, is neither the supplier nor the user, pays for the installation and is responsible for its operation and maintenance costs. The third party buys heat from the supplier at a lower price and sells the same heat to the user at a higher price. In this case the heating cost savings (benefits) to the user are reduced as the third party claims the larger part of the savings as a return on investment.

Supplier Owned Installation

The supplier pays for both the recovery and the distribution system and is responsible for all operations and maintenance costs. The user pays for the heat delivered at an agreed rate which will be higher than the split ownership rate.

User Owned Diesel Generator WHR/D

The user purchases a diesel generator(s) with factory installed heat recovery equipment and connects the distribution system into his own building. In this case, the user purchases diesel oil and is responsible for the operation and maintenance of all equipment. The savings in the cost of both heat and electricity with this arrangement is considerably more than other WHR/D options.

The option which may be best for a community depends on many considerations. Such considerations require

- the cooperation between the customer, the supplier and other involved parties;
- a thorough pre-project investigation, financial and economic analysis supported by good cooperation and communication among the groups involved. (See Section 4.8.)

E. - Financing Options, Regulations and Constraints

Assuming the pre-project investigation (Appendix E) indicates that the proposed WHR/D is financially and economically beneficial, funds are required for a feasibility study and the project capital costs.

The pre-project investigation should be sufficiently complete and appropriately prepared such that funding agencies can understand the project objectives, costs, and benefits. Several sources should be contacted to find the most economical choice. Depending on which ownership option is preferred, both the supplier and/or the user arranges for the required funding. Financial options used in previous projects include the following:

- commercial loans,
- loans from the supplier,
- use of part of the native band's annual allocation,
- funds borrowed through government sources,
- funds borrowed through the suppliers sources,
- independent investors,
- leasing arrangement,
- government assistance.

The following assumes that the participants have selected a split ownership arrangement. Financial options are discussed from the supplier's and user's perspective.

Supplier's Financing Options

Funds for capital project within utilities are raised either from funds from operations or borrowed on the commercial market, depending on the amount required. If approved in the annual budget, the funds are then made available. This process may take as long as one year. The customer should be aware of this supplier's time constraint when utility funding is involved.

Another supplier constraint can be the number of competing projects seeking funding in the same budget-year. The utility will have a limit to the annual amount of money available for capital projects.

User's Financial Options

The user's financial options depend on who the user is, a school board, public works, a hospital board, a religious order, the town council, the native band council or a private company. All have financial constraints of one type or another.

Government service groups and other agencies in communities are required to obtain approval for entering into agreements and for project funding, from their respective ministries. Depending on the level of governments involved, such approvals may take as long as one year to obtain.

Depending on how the band allocation or municipal budget is administered, approval to use any portion of the annual allocation may also take up to one year. This may or may not involve Indian and Northern Affairs Canada.

Depending on the nature of the Heat Supply Agreement and the regulations and constraints facing the user, project capital funding may be arranged through:

- commercial loans,
- equipment leasing,
- tariff arrangements with the heat supplier.

Loans are straight commercial agreements with a bank or other lending institutions. Arranging approval for a loan and obtaining an affordable interest rate requires that the lending institution understand fully the objectives, costs and financial benefits of the project. They will require a business plan showing where the money is to be spent and from what sources the money is to be repaid. This should be supported by expert's or supplier's feasibility study to show the project is technically, financially and economically feasible. Reductions in interest rates may be obtained using government loan guarantees. These cover the project costs in event of failure and alleviate some of the risk to the lending institution. In certain cases, the governments may assist with a capital grant where the project demonstrates significant social benefit and merit.

Corrective Action

Project participants should be prepared for things that can go wrong such as a strike at the equipment manufacturer's plant, lost or misplaced shipments of parts and materials, late deliveries, theft or vandalism. All of these will add to the cost of a project. If they are not acted upon quickly, the additional costs become greater with each passing day.

It is all too easy for a not so well managed project to get out of hand where project costs are overrun by 50%, sometimes 100%. Overruns can turn a potentially good project to a money losing investment.

Depending on the type of contract and how far the contract has proceeded there are several steps that can be taken. The first step is to have the committee meet, to explain, research and find a solution to the problem. These may include such actions as:

- contract cancellation and hiring another contractor;
- pulling the equipment out of the stricken manufacturer's shop and having the work completed by another manufacturer;
- contacting the president of the organization involved, explain the problem and demand swift remedial action;
- threaten legal action or back charges;
- meet with the contractor and demand a corrective action plan;
- have all project equipment and material insured during construction.

For corrective action solutions, the heat supplier, (who typically has considerable experience in dealing with project problems and contractors), can usually provide much needed advice and assistance.

Since financial management and control is so important to the success of the project, and because the supplier's organization has the experience and facilities in place for this purpose, in most cases, the supplier's representative is chosen as the project manager.

Leasing arrangements are offered by some lending institutions where the user or supplier leases the equipment until the principal, interest and profit to the leasing company is repaid. In this situation the leasing company owns the equipment and there is a percentage charge above the normal cost of the project to cover the risk and administration required. While the net cost of the heat through leasing may be more costly to the community, these companies do provide a service that might otherwise not exist.

A tariff arrangement may be possible between the user and the supplier where the supplier covers the entire system and recovers the cost using an adjustment to the heat purchase rate.

Government Support

Governments, both Federal and Provincial, may have programs in place to provide information, advice and/or financial support. The feeling in most governments is that if a project is shown to be both financially and economically feasible it should be self-financed.

Both federal and provincial/territorial governments should be contacted regarding programs and advisory services.

F. - Heat Supply/Purchase Rate Structure Determination

If a purchased heat approach is selected, the agreement covering the rates for the heat supplied is the next most challenging step. While considerable money is at stake, these negotiations can be positive and friendly if each party appreciates the other's point of view. Each party will have their own goals. The customer will want to reduce the annual heating costs without losing the security of having heat when needed. The supplier will want to cover plant modifications, additional operating and maintenance costs as well as maximize revenues from heat sales.

Both the supplier and user should have equal payback periods, and as much as possible, the fuel savings should be divided equally between the two parties. In the case where the user can take only part of the available recovered heat, a "pro-rata" heat purchase rate is desirable where the user pays only his share of the cost of heat. In applying these guidelines, consideration must be given to what is called the "threshold rate". This is the rate above which the user does not have sufficient net savings to make the project worthwhile and below which the supplier cannot justify the expense and trouble

of installing a WHR system. Providing the financial analysis indicates a net savings over project variable and fixed costs for both the supplier and user, there is room for negotiation. Appendix B contains an example of a cost sharing agreement.

G. - Financial Controls

Assuming that project funding has been arranged, the successful completion of a WHR project within the budget allowed requires good money management and financial control.

Project Expense Planning

Project expenses during construction, and cash flow during operation should be planned well in advance so that participants know when project expenses should occur, the amount of the expense, and what service or equipment each expense is for. Without expense planning, project funding could be used for arbitrary items causing the project to run out of money before the installation is complete and operational.

Project Expense Implementation

When equipment is ordered or a contractor is hired, a specified amount of the project funding is committed to that purpose. The equipment supplier or contractor is paid according to the progress made in providing the equipment or services specified. A normal pay schedule would allow

- 20% of contract price on award,
- the next 30% at the 50% completion mark,
- the next 40% at contract completion, and
- the remaining 10% after all defects are corrected and specified performance attained.

The reason for using this type of pay schedule is to allow proper control of expenses.

Control of Expenses

There are three elements to controlling project expenses as follows

- approvals,
- recording and monitoring,
- corrective action.

Recording and Monitoring

A record should be kept of all project expenses for both community accountability and taxation purposes. Accountability means being able to show where and for what purpose each dollar was spent. Tax deductions require supporting records and receipts.

Monitoring applies to two areas. The first area is monitoring the remaining amount of funding to complete the project. This can be compared with the remaining planned project expenses. If the remaining funding will not cover the remaining planned project expenses, action should be taken as early as possible to either arrange for more funding and/or reduce remaining project expenses.

The second area of monitoring is the progress of awarded contracts. These must be watched very closely to avoid expensive deviations from the specified deliverables and slippage in schedule. Both can incur very undesirable additional costs and delays in project completion.

Corrective action requires vigilance on the part of the participants to ensure that the specified services or equipment are properly delivered. In most cases, notification to the remiss third party will be adequate. In extreme cases, withholding payment or even legal action will be required.

Economic and Social Considerations

6

WHR/D COMMITTEE



VI - ECONOMIC AND SOCIAL CONSIDERATIONS

A. - Economic Considerations

In Chapter 5, the comparison of costs with financial benefits was discussed, however, in remote communities there are other considerations which affect how any large part of the annual allocation is spent. While the financial analysis looks only at one project, the users economic analysis looks at the true value of several projects to the community to determine which project or expense makes better use of community money. This includes services such as health, housing, or education. Similarly, the supplier's economic analysis compares the benefit from the project versus the benefit of other possible projects. These are the elements of economics.

There are several interests and concerns which both support and oppose such projects. The following relates some of these issues as seen from the user's and supplier's perspective.

User Interests and Concerns

The user's economic interests and concerns deal with the priority of needs within the community. With growing populations, the immediate need for housing, education, medical, security and public facilities may appear to be more urgent than energy conservation. There is also the issue of who benefits from the energy conservation project, the community or the rate payer. Two further concerns are the level of benefit and the problem of comparing an energy conservation benefit (which can be easily measured in dollars) to the benefit of education or housing (which is necessary but difficult to measure). The costs of these may be known but the true value of the benefits are not. All things cannot be directly measured in money.

Most potential users of recovered heat are not technical people. They are either band, government, or service administrators. Their concerns include

- lack of understanding of what a waste heat recovery distribution system is or how it works,
- lack of cooperation from all other parties involved,
- lack of control over the final cost of the installation,
- reliability of the heat supply,
- the possibility that the installation will not perform as specified with the result that the benefits from the cost will be less than expected,
- changes in the price of heat due to changes in the price of oil,
- competing community needs.

The concern of competing community needs should be dealt with by separating these needs into short-term and long-term needs. The use of recovered heat is a long-term issue and should be compared with other long-term community opportunities rather than the many short-term needs. This allows a comparison of benefits from competing projects on an equal footing.

Supplier's Interests and Concerns

Utilities lose money on remote community operations. While some customers pay their electricity bills others cannot.

The utility (supplier) has two concerns. As a public utility, (most utilities are) their purpose is to serve the public and increase their quality of life through the provision of electricity. While they are not expected to make profits on their operations, they are, likewise, not supposed to lose money. Why then should a utility invest more money into a community where operations run at a loss?

A second concern is electricity cost subsidization. Since the production of electricity in remote communities is subsidized, the supply of recovered heat may also be viewed as subsidizing heating costs, most of which are already subsidized. Certain government agencies, in an effort to control the amount of subsidization, may view the recovered heat sales as a method to reduce the level of subsidies to commodities. This could create problems during discussions with communities or agencies.

Utilities employ mostly technical people whose strengths lie in building, operating and maintaining equipment rather than initiating projects and negotiating with government agencies or band councils. Consequently, the utilities are concerned with the following:

- the frustration of dealing with several government agencies, the substantial amount of pre-project negotiation, discussions and communication between the various groups, the indecision or continually changing commitment of various groups as well as the very complex political issues involved in remote community funding;
- the ability of the user to maximize the use of recovered heat and maintain the distribution equipment;
- reliability of the supply of recovered heat and of the electrical generating equipment.

Possible Solutions

In the user's situation, the perceived lack of cooperation may be the same amount of "red tape" faced by the supplier. The solution is to keep the number of groups involved to a minimum. In the case of Attawapiskat, the main involvement was limited to Ontario Hydro and the James Bay Hospital Board. In other projects where more than three groups or agencies were involved, the projects were faced with several interruptions and postponements.

Concerns, such as lack of project cost control, heat supply reliability, and underperformance, are resolved by a thorough pre-project investigation. These valid concerns reflect the fact that any increase in cost or reduction in benefit will adversely affect the economics of both the project and the community. Through the pre-project investigation, the user will be aware of how project costs are controlled, the quantity of heat available, the reliability of the diesel units and the performance of other similar installations.

The supplier's concern of the user's ability to maximize the use of recovered heat and maintain the distribution equipment is solved by on-line monitoring devices. These signal the supplier whenever heat delivery is interrupted and the outdoor radiators are used. The supplier can then investigate the cause of the interruption and take corrective measures.

B. - Institutional Considerations

In economic considerations, the merits of a WHR/D project are compared on a cost versus benefit basis. Under institutional considerations, the applicability of the project is compared with the intent of ongoing government programs (or laws), as well as the supplier's corporate financial management system.

User's Perspective

The user may be part of an administration with certain programs or laws in place, which may limit the use of funds available for energy projects. For example, a Ministry of Education may feel that their purpose is to deliver educational programs not energy programs, even though conventional building heat may command a large proportion of the annual budget.

A further institutional consideration is the lack of access by specific user groups to commercial loans or equipment leasing agreements. For example, a community's financial or legal position may not allow lending institutions to loan the community funds for capital projects. A possible solution to this problem is government assistance in the form of loan guarantees.

Supplier Perspective

Canada has both private and publicly owned utilities. All are regulated under acts of government concerning their operation. Depending on the amount required for the project, the utility may either borrow the funds on the commercial market or use funds from other operations. Regardless of the source, the requirement for funding may have to compete with other utility projects under consideration. If other projects offer greater returns on investment, they may be selected over the WHR/D project.

Since operations in remote communities are usually unprofitable, the sale of recovered heat is an opportunity to reduce or eliminate these losses. From an economic standpoint this may provide equal benefit to other projects under consideration.

Public utilities may have other incentives to participate in WHR/D projects particularly where territorial, provincial or federal government encouragement is present. Government services form a major part of customer demand in remote communities.

C. - Social Considerations

The major benefit from a WHR/D installation is the additional services that can be provided with the money saved using recovered heat. In the Attawapiskat example, the James Bay Hospital Board has already repaid the system capital costs and now saves approximately \$14,500 each year in avoided fuel costs.

A secondary benefit of a WHR/D project is employment for local contractors, labourers, and trades persons during construction. There is also operator training associated with the new equipment.

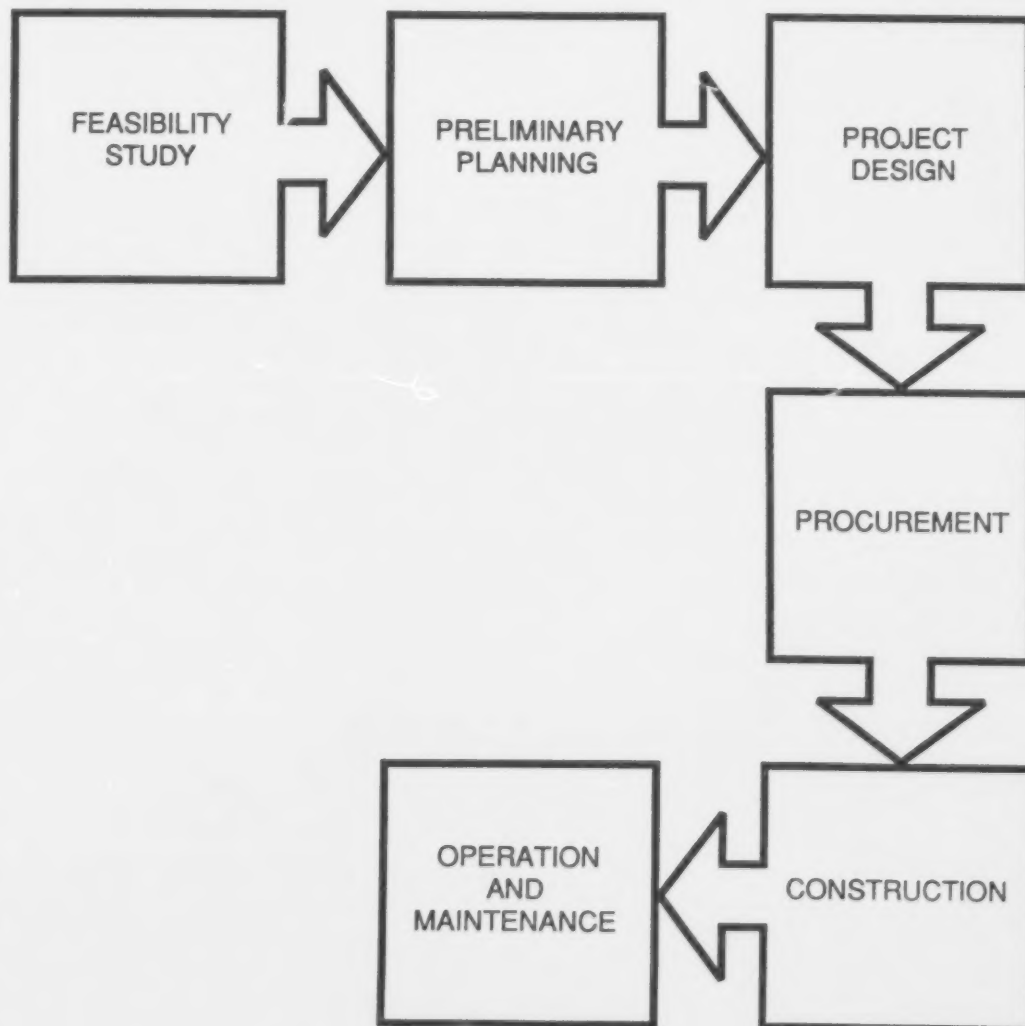
Training should be provided to the user's staff to recognize when oil heat is used rather than recovered heat. While typical users, such as administrators, teachers or nurses, cannot be expected to repair heating equipment, they can telephone the supplier to arrange for a technician to correct the problem. This training may have application to other community activities.

In most previous WHR/D projects there was no loss of local employment as a result of the new system. The net social impact in most cases is positive, particularly where funding to the community has a ceiling level across all services. Since the amount of funding coming into the community is limited, the savings in oil costs made funds available for other services such as health or education without an overall increase in budget.

In the case where savings do not accrue to the community, there is a benefit to the ratepayer through the reduction in cost to provide services in remote communities.

Technical Considerations

7



VII. - TECHNICAL CONSIDERATIONS

A typical WHR/D project has many technical considerations dealing with:

- the size of the system,
- the type and location of equipment,
- the amount of heat delivered.

This section provides guidelines for a committee who may not be technical experts but have to deal with technical considerations. All electric utilities (suppliers) have technical people who can determine the amount of heat available and the heating requirements of each building. In many cases the supplier has been willing to provide technical assistance to the community to look at the feasibility of using waste heat recovery and its applications.

Lack of understanding of the function and operation of a WHR/D system is a real but not permanent obstacle. Perhaps the easiest way of explaining the heating capabilities of recovered heat to users is to give a tour through the diesel power plant, explaining in particular the components and function of the diesel cooling and exhaust systems. Next, descriptions of diesel waste heat recovery systems now operating in other communities should follow. The third step is to conduct a tour of the user's building concentrating particularly on the heating system. Explain how oil is converted to heat then circulated throughout the building. Then explain how the heat from the diesel cooling system can replace the heat from the oil used in the user's heating system.

This may sound somewhat elementary but the process, which may have to be repeated for each involved group, is a very effective means of information sharing.

This section describes the more important technical considerations and how they are helpful in looking at a WHR/D project.

A. - Feasibility Study

What is a technical feasibility study and why is it so important? When should such studies be done? A feasibility study is a technical, professional or expert investigation of a WHR plan for a project. It answers questions such as:

- How much heat do the selected buildings need each year?
- How much heat can the diesel generators deliver?
- What type of equipment is required?
- Where should the equipment be located?

A feasibility study incorporates information specific to the community such as:

- the distance between the source of the heat and the user's building;
- the type and amount of pipe required;
- the cost of the equipment, the piping and, labour to install the system;
- the amount of heating oil that can be saved each year;
- the amount of money saved by using recovered heat instead of using heating oil;
- the number of years of operation required for the savings in heating oil to pay for the recovery and distribution system;
- any problems which would prevent the use of a WHR/D system;
- possible alternative options to save heat, diesel oil or heating oil.

To develop a WHR/D feasibility study, the consultant, expert and/or the supplier will use the information gathered in the pre-project investigation, such as:

- the number of hours of operation for each diesel during the past two or three years;
- the quantity of electricity produced. This is important as two kilowatts of heat are available for each kilowatt of power produced;
- the timing of peak electrical demand loads compared with peak heating demand loads;
- the amount of heating oil used by each large building as well as the insulation rating of each;
- the type of heating system used in each building, and its suitability to use recovered heat;
- the condition of the ground between the diesel plant and the building. Is it easy to dig through? How much will it cost to bury the distribution system?;
- the suitability of using aboveground lines without getting in people's way;
- the location of buildings to be heated. How far are they from the diesel plant? Are there other buildings, roads or obstacles between the supplier's plant and the customer's building?;
- the importance of the heating requirements. A hospital cannot operate without heat, but a community centre could be closed for a short time while heating is restored;
- the community's development plans. Would the distribution system interface with future buildings, roads, sewers or water mains?;

- the financial capability of the community.

What should the committee expect from a full feasibility study? The completed study should contain

- (a) A Site Survey summarizing the location of large buildings, their peak and annual heating requirements, the amount of available waste heat, the effect of any planned community or diesel plant changes and any valid major concerns of either the supplier or the customer.
- (b) A Technical Evaluation indicating whether a WHR/D installation will perform in the community and how much heat it would deliver.
- (c) A Financial Evaluation indicating whether or not the WHR/D installation will pay for itself through heating oil savings (net present value of zero or greater) and how many years of operation are required to pay for the installation (payback period).
- (d) An Economic Evaluation indicating the benefit to the community for the cost of the installation.
- (e) A Legal Evaluation indicating legal obstacles which need to be overcome such as right-of-way approvals.
- (f) An Environmental Evaluation indicating if the proposed installation will pose any threat to the community's health, land, air, or water.
- (g) Recommendations indicating whether it would be wise to install the WHR/D system and which would be the best arrangement compared to the cost.

B. - Preliminary Planning

Assuming that the feasibility study indicates the proposed WHR/D project merits further development, the next action by the committee is preliminary planning. Preliminary planning is carried out by the supplier's or the user's consultant or possibly both working together. The objectives of preliminary planning are to:

- take accurate measurements of the distance between buildings and any obstacles in between;
- develop a schedule showing when it is the best time to conduct project activities such as excavation, construction or commissioning;
- prepare a list of all supplies, services, materials and equipment required for construction and commissioning. These are not the equipment or material that make up the WHR/D system but items like backhoes, shovels, timber, gasoline and meters used during construction and commissioning;
- prepare a plan of action supporting the schedule explaining what work is to be done during each phase of the schedule;
- develop a detailed estimate of all project costs;
- develop a proposed layout for the installation showing the location of all equipment, pipes and controls. This is required to obtain construction permits and right-of-way approvals.

These plans and this information are necessary to develop the design of the installation and arrange for construction activities to complete the installation in the time specified.

The completion of preliminary planning is important for the following reasons:

- the detailed estimate will give the most accurate indication possible of the total project cost before the final decision is made to proceed with the project;
- the schedule and plan of action will show where project costs can be expected. Together with the detailed estimate, these aid the committee in maintaining cost control over the project.

C. - Design

The design of the installation is done by either the supplier or consultant or both acting together. The objective of the design phase is to produce

- a detailed design showing exactly where all equipment is to be located and how it is to be installed,
- specifications for material, equipment and construction services,
- bills of material listing all equipment, materials and supplies necessary.

The importance of these products is that they describe in detail the equipment, materials or services required such that the committee and the potential contractors understand to full, requirements of each project cost. These drawings and specifications provide the committee with a yardstick to compare the contractor's performance. This in turn will determine if the contractor should be paid. This gives the committee financial control.

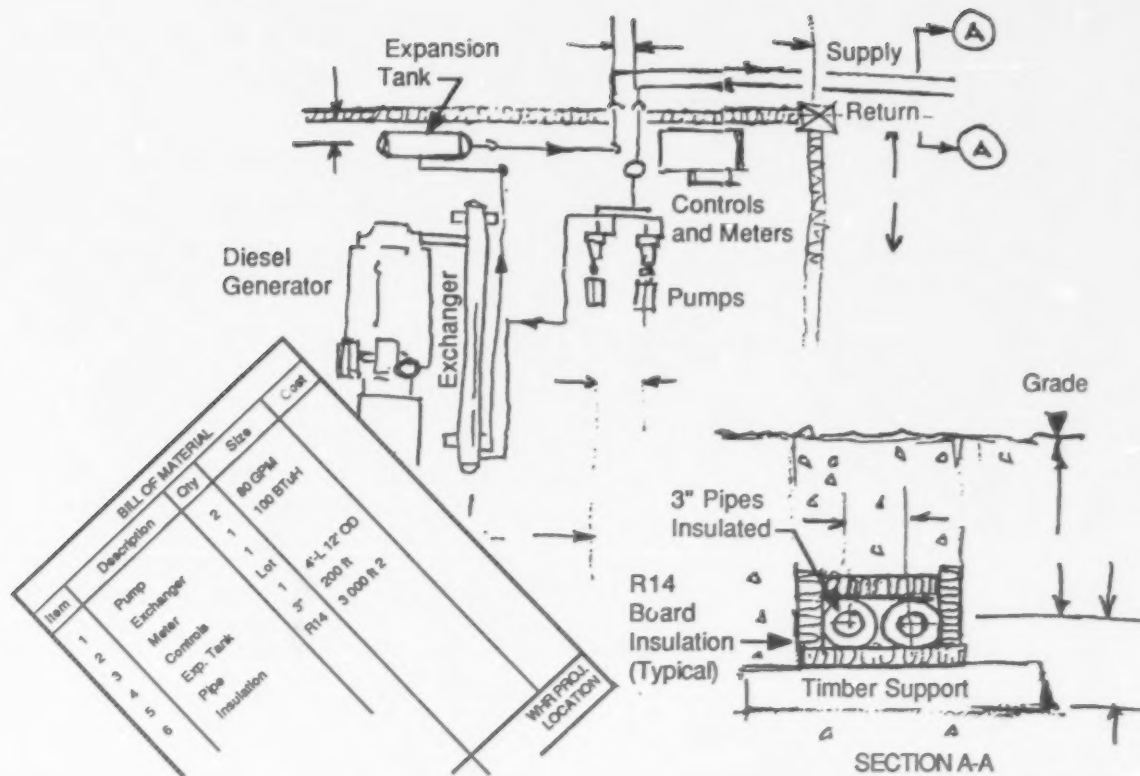


Figure 7.1

BURIED SUPPLY AND RETURN PIPING FOR PERMAFROST INSTALLATION

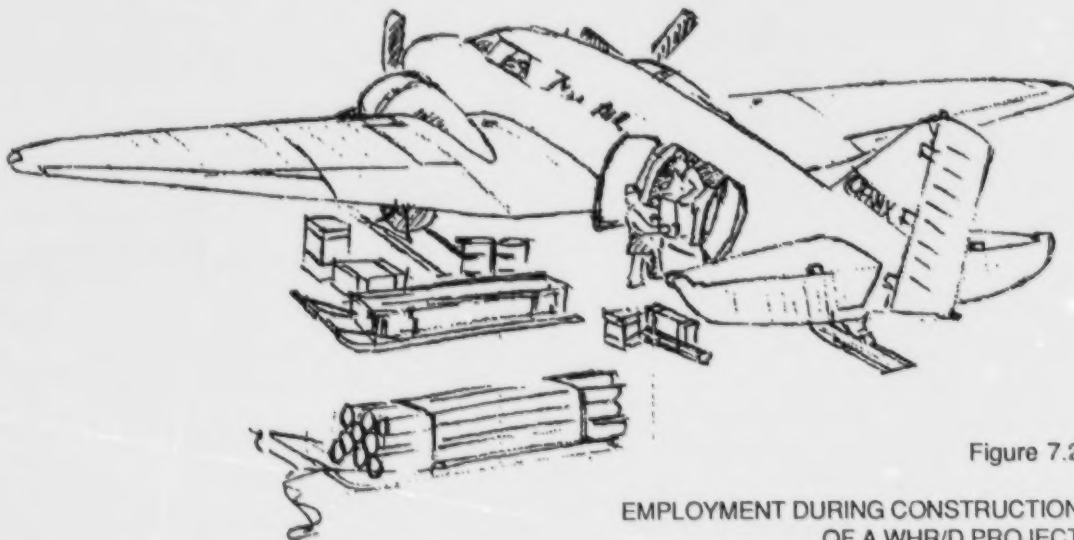
D. - Procurement

The specifications developed in the Design phase can now be issued to contractors to obtain their bids to perform the required services or provide equipment or material. By these specifications the contractor will be aware of the project schedule requirements. This is important because delays in receiving equipment or material in the community will add to the project cost.

When the contractors' bids are received, they are compared for product, price, and schedule. The best combination of these is selected and contracts awarded. The committee or its representatives should now monitor these contracts to ensure the contractors stay on time and within budget.

E. - Construction and Commissioning

The successful construction contractor brings his equipment and personnel to the community at the time specified in the schedule. The contractors will arrange with the town and band council for trades and labour. This employment opportunity is important to the community and they should be made aware in advance that their services may be required.



The equipment and material is transported to the community to coincide with the contractor's arrival, and the systems are installed.

Selected user and supplier operating staff must participate in the commissioning of the system. This training, which is very important to the operation and maintenance the system, should be part of the contractor's specified work.

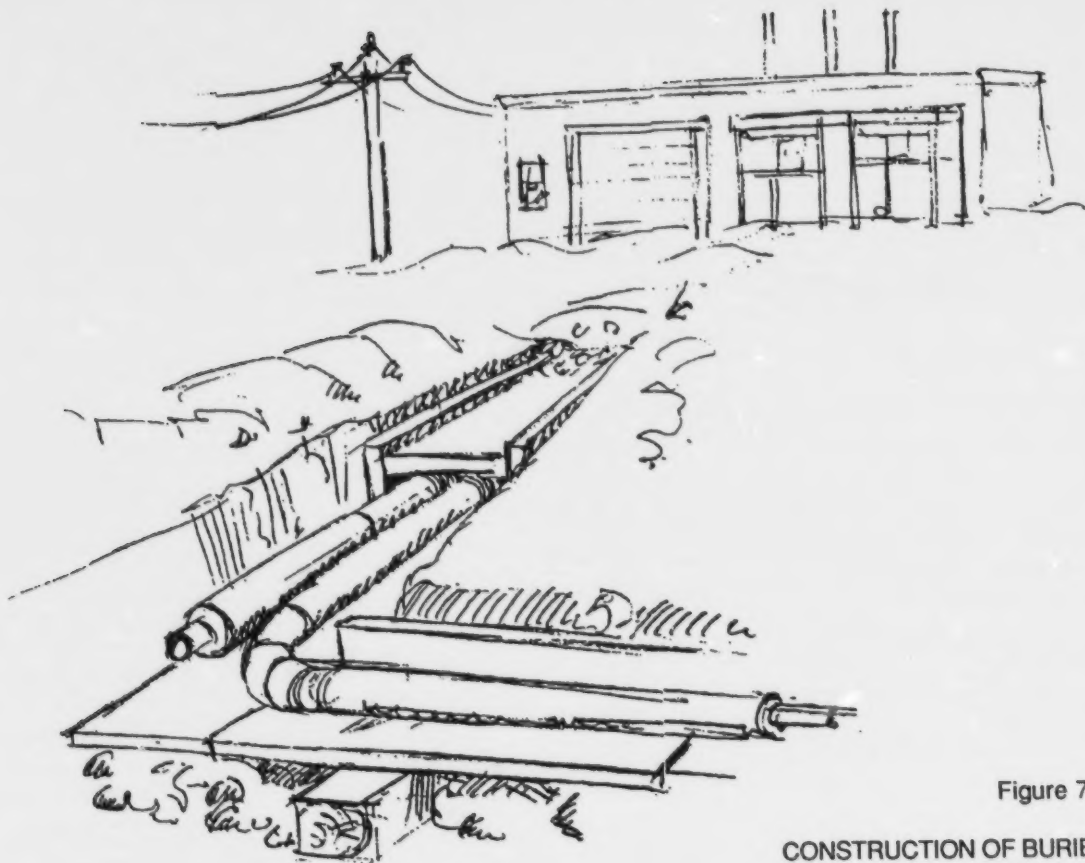


Figure 7.3

CONSTRUCTION OF BURIED DISTRIBUTION LINES

During the commissioning records must be kept of the system's performance. This includes the temperature of the heat delivery solution going to the user and returning to the supplier. Temperature measurements of the supply and return solution in the user's heating system must also be taken. These are compared with the system design specification. If performance is less than specified, the benefit from the system is reduced (less benefit for the same cost). This calls for corrective action on the part of the contractor to bring the system up to specified performance or better. It may be as simple as purging air from the circulation lines as in our Attawapiskat example.

F. - Operations and Maintenance

With the system installed and operating there is the further requirement to continually monitor the performance of the system. The supply and return temperatures should be recorded each day. If the supply temperature falls or if the system breaks down, the benefit is reduced or temporarily lost. This situation calls for corrective action and/or maintenance.

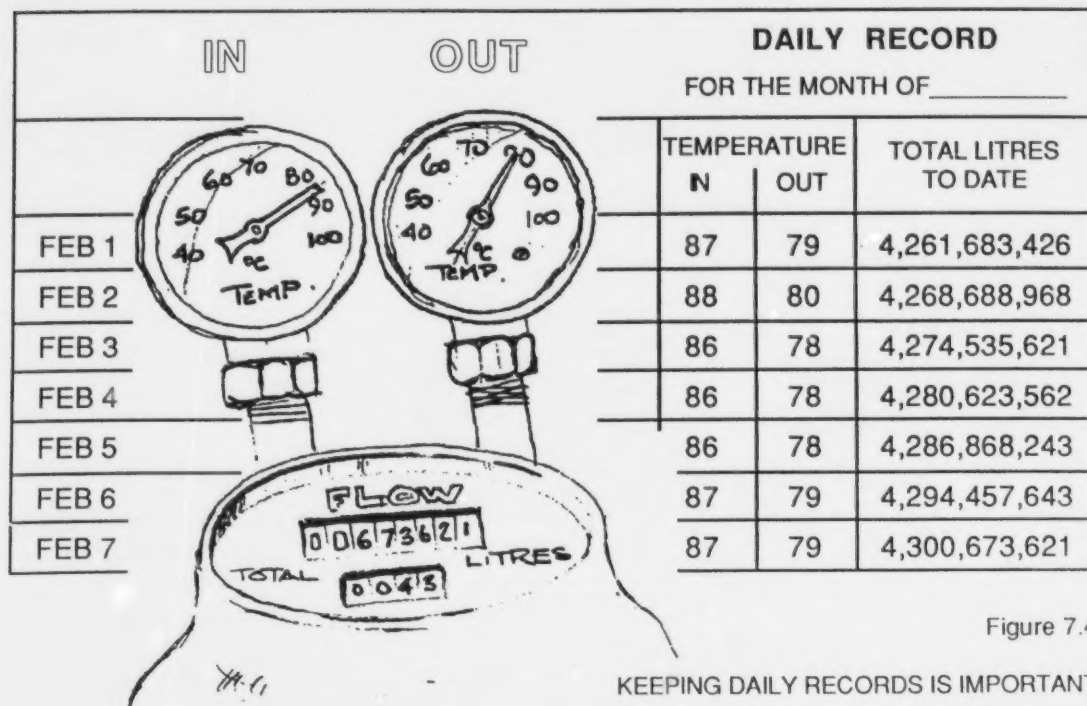


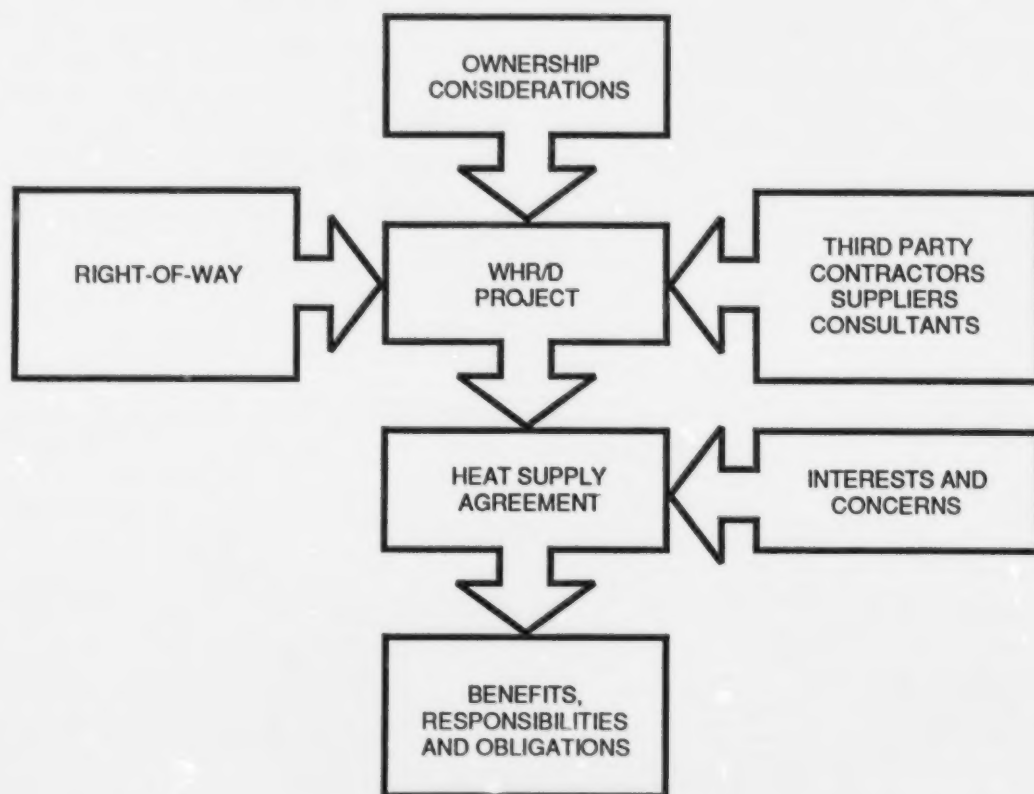
Figure 7.4

G. - Guide to Hiring a Consultant

This manual is not intended as a promotion or recommendation of any particular consultant, or consultants in general. The intent is to make communities aware that some consultants have considerably more experience with WHR/D systems than others. This experience is important to all parties involved in a WHR/D project as it affects the cost of the project. The use of an experienced consultant can save a project considerable money, avoid delays and help with solutions to non-technical problems. A listing of contractors, suppliers and consultants who have WHR/D experience is presented in Appendix C.

Communities should assess with care the use of consultants inexperienced in WHR/D. While they may be technically competent, they may not be able to deal with financial and project management problems associated with remote community WHR/D projects.

Legal Considerations



VIII. - LEGAL CONSIDERATIONS

Since the installation of a WHR/D system involves considerable expenditure and effort on the part of both the supplier and the user, a legal agreement is required to safeguard the interest of all parties concerned. All signatories to such agreements must be legal entities. Not all remote communities have a legally recognized status. Legal considerations may involve

- the supplier,
- the user,
- third parties such as contractors, lending institutions, equipment suppliers,
- the community or town government,
- the provincial or territorial government, and possibly
- the federal government.

A. - Contractual Considerations

The development of a WHR/D installation from the planning stage into an operating system will have various legal considerations during each phase. Normally, the four major contractual considerations are

- the Heat Supply Agreement,
- contracts with third party consultants,
- contracts for equipment or construction services,
- right-of-way acquisition.

Heat Supply Agreement

A major step in a WHR/D project is the development of the Heat Supply Agreement, an example of which is outlined in Appendix B.

Basically, the agreement defines who is responsible for which part of the system, who pays for each part and who operates and maintains the respective parts. If necessary, the rate at which the heat is sold is also specified. The agreement must also cover the concerns of the parties involved.

If applicable, negotiations concerning the rate paid for the heat should be conducted with the view that a reasonable rate:

- allows the capital cost to be recovered in a reasonable span of time (five years is considered reasonable);
- recognizes that the price of oil will change over time; and
- meets both the supplier and user cash flow requirements.

Operating, maintenance and possible replacement costs should be taken into account during the rate structuring process. The agreement should also recognize that the supplier may have an opportunity to use some other way to produce electric power other than diesels. Above all, the agreement must be equitable to all parties concerned.

A further consideration is the project schedule for both supplier's and user's parts of system. These should be constructed during the same time period. A mismatch or delay in either schedule would leave the other party with the burden of paying for their part of the system with no benefit.

Legal Responsibilities and Obligations

Both the supplier and user should be responsible for completing their portion of the system in the agreed time period and maintaining their system in proper working order once in operation. They have an obligation to each other to inform each other of any changes to their parts of the system that would interrupt or adversely affect the performance of the system. Periodic inspections of the user's distribution system should be permitted by the supplier's representative, particularly after any repairs, maintenance or modifications have been made. Such changes should be discussed before they are made. Depending on the circumstance, the other party should be informed accordingly; major upsets should be reported immediately while a planned maintenance outage should be discussed several months in advance.

Heat Supply Interruptions

In most agreements, the supplier will likely specify that the utility will supply heat when electrical production makes heat available and will not be held liable for damages when it cannot. This means the user must have a backup heating system to provide heat when the recovered heat is not available. Most previous WHR/Distribution systems have proven very reliable when maintained and operated correctly.

Ownership - WHR, Distribution and End Use Equipment

In previous heat supply agreements the party who benefits from the use of the equipment is responsible for repaying the debt for the equipment and maintaining the equipment in proper working order. Proper maintenance of each part of the system requires that the respective operators be properly trained to identify problems which may arise during operation and to perform the necessary repairs as soon as practically possible. This also requires that each party stock the necessary spare parts equipment and material to perform the repairs.

B. - Right-Of-Way Acquisition

The distribution system transports the heat from the diesel power plant to the user's building through insulated supply and return pipes. These pipes may be located above ground or buried. While installing pipes above ground may be less expensive, there is the concern of right-of-way. If the user and suppliers building are a short distance apart and above ground pipes do not interfere with vehicular or pedestrian traffic, there is generally not a problem with getting right-of-way approval. Generally, no approval is required if the supplier's and user's properties are adjoining.

For situations where the distribution pipes must cross streets or property, a buried distribution is used. Before a distribution system can be put in place, approval must be obtained from the town, community provincial or federal government with authority over the property, particularly when the system crosses any vehicular roadway. Normally, approval will be granted if proper precautions are taken to safeguard both the system and the public. In these cases, the government is concerned about their liability to the public, interference between the distribution system and planned future public works and protection of the environment.

There is the particular case where project costs could be reduced if the distribution system were allowed to cross private or public property. If this property happens to be an airport, right-of-way will most likely be denied. If this property belongs to a private residence, the permission of the property owner is required.

In most communities where the distribution pipes must run a fair distance, they are located next to the communities water and sewer lines on town road shoulder property.

C. - Third Party Participation

The design for construction of a WHR/D system may require the services of a third party contractor. Most contractors are reputable and will provide the service contracted for within the time frame specified. Contractual consideration when dealing with experts or contractors should be clearly detailed. Both supplier and user should be allowed a review of each others contracts for third party participation, particularly before any binding contracts are signed. Normally, contractors who work closely with the supplier and the customer provide the best service.

Appendices

APPENDIX A

SUMMARY OF CURRENT POLICIES REGARDING WHR

In preparing this manual utilities were asked if they now have in place a policy covering diesel waste heat recovery and sales. As of 1987 none had a formal policy in place, however, all utilities were either very positive about supplying waste heat, or some cases agreeable but cautious. Since there are no formal policies in place, the following can only generalize their position towards WHR/D.

Newfoundland

Newfoundland and Labrador Hydro
Philip Place, Elizabeth Avenue
P.O. Box 9100
St. John's, NF
A1A 2X8
Contact: Manager of Diesel Electric Operations
(709) 737-1400

Newfoundland and Labrador Hydro is quite interested in WHR/D. Although no policy has been established the utility is agreeable to cooperating with seriously interested proponents to evaluate opportunities for WHR/D on a case-by-case basis. Where warranted, Newfoundland and Labrador Hydro technical personnel will assist in WHR evaluation and development.

Quebec

Hydro Quebec
505 de Maissoneuve East
Montreal, PQ
H3A 3C9
(514) 289-4124

Quebec Hydro is agreeable to providing diesel waste heat to any interested community. The current Quebec Hydro position is that the heat can be provided if the community will pay for both the heat recovery and distribution systems as well as any additional costs to operate and maintain the WHR/D system.

British Columbia

BC Hydro
970 Bernard St.
Vancouver, BC
V6Z 1Y3
Contact: V.P. Marketing
(604) 663-2223

British Columbia Hydro is agreeable to supplying diesel waste heat to any interested community providing the community pays for both the heat recovery and distribution systems as well as any additional costs to the supplier to maintain and operate the WHR/D equipment. Other than these costs, the heat will be provided free of charge.

British Columbia Hydro is following a long-term policy of phasing out its diesel plants where possible by new grid extensions and development of small hydro. This does not mean that all the diesel units will be replaced but that WHR/D proponents should be aware of this policy.

Manitoba

Manitoba Hydro
820 Taylor Avenue
P.O. Box 815
Winnipeg, MB
R3C 2P4
Contact: Senior Department Manager, Generation Engineering
(204) 474-3311

Manitoba Hydro has assisted in the evaluation and development of WHR/D. Although Manitoba Hydro does not have a formal WHR policy, they are agreeable to supplying diesel waste heat for the cost of modifications and additional operational requirements. The customer pays for the diesel modifications and distribution system.

Saskatchewan

Saskatchewan Power Corporation
2025 Victoria Avenue
Regina, SK
S4P 0S1
Contact: Chief Engineer
(306) 566-2121

Saskatchewan Power has a similar stand to Manitoba Hydro concerning WHR. Each application is evaluated on its own merits.

Alberta

Alberta Power Ltd.,
10035 105th Street
Edmonton, AB
T5J 2V6
Contact: Manager North Division
(403) 420-7627

The Alberta Utilities have been very active in promoting the use of recovered waste heat. Their unofficial policy is to equip all new and replacement diesel units with waste heat recovery equipment for future

applications, and to move all new facilities to the outskirts of communities, away from buildings.

Northwest Territories

Northern Canada Power Commission
P.O. Box 5700
Station L
Edmonton, AB
T6C 4J8
Contact: Manager of Engineering
(403) 465-3377

Northern Canada Power Commission has, for considerable time, made as much use as possible of diesel waste heat for utility residences, maintenance garages and government buildings. They are agreeable to supplying recovered diesel waste heat to communities, providing the customer pays for and installs the recovery and distribution equipment. The operations of the Northern Canada Power Commission in the Northwest Territories are being transferred to the government of the Northwest Territories.

Yukon

Yukon Electrical Co. Ltd.,
P.O. Box 4190
Whitehorse, YK
Y1A 3T4
Contact: Technical Supervisor
(403) 667-2494

Yukon Electric is similarly interested in the beneficial use of reclaimed waste heat. Although there is no formal policy in place, all replacement and new diesel units are equipped for heat recovery. Yukon Electric does not have a strict pricing policy for the sale of heat. Each application is evaluated on its own merits.

Ontario

Ontario Hydro
700 University Avenue
Toronto, ON
M5G 1X6
Contact: Manager Remote Power
(416) 592-4728

Ontario Hydro is an active promoter of WHR and is currently developing a policy to cover its application. Ontario Hydro prefers to install their own recovery equipment with the customer supplying the distribution system. All new or replacement Ontario Hydro diesels are purchased with WHR equipment installed.

Nova Scotia, Prince Edward
Island and New Brunswick

These provinces are not considered to have remote communities. The exclusion of their utilities from this manual is not a reflection of their position or policies towards WHR/D opportunities.

General Utility Position

As a general statement, all utilities serving remote communities are aware of the benefits of recovered diesel waste heat and are agreeable to assisting communities in evaluating their potential. Reasonable requests for information and assistance will be answered. The cost of the heat supplied depends to a large extent on capital investment the utility must make to add and maintain WHR equipment. In most cases, the heat sale agreement made with the user will provide the required heat at costs substantially lower than using heating oil.

APPENDIX B

EXAMPLE OF A HEAT SUPPLY AGREEMENT

Waiver

The following example agreement is provided for guidance only. The actual agreement should be reviewed by both the supplier's and user's legal counsel.

As mentioned earlier, there are two separate major costs forming part of the agreement. The first is the capital cost covering all equipment, material and services required to put the WHR/D system in place. The second is the operating and maintenance cost covering the heat sold and the repair or maintenance of equipment. With paybacks of three to five years the second cost is normally the major component of the agreement. As a guide the agreement should contain the following sections.

1 - INTERPRETATION

This section defines

- who are the supplier and the user of the heat,
- for which building and purpose the heat is to be used,
- the system used to convey the heat,
- all participants to the agreement including the supplier and customer,
- the quantity of waste heat available and the conditions under which

the heat will be made available.

2 - SUPPLY OF HEAT

This section defines

- the primary function of the utility (to supply electric power) and the conditions regulations and restrictions under which it must operate,
- the cost at which the heat is supplied,
- the responsibility of both the user and supplier to put in place their respective portions of the recovery/distribution system to convey the heat,
- provision for future changes to the WHR/D system to allow for diesel changes, beneficial modifications, and addition of future customers,
- waivers to protect either party for damages due to negligence or adverse circumstances,
- responsibility for operation and maintenance of the system.

3 - OWNERSHIP

This section defines

- who owns each part of the system,
- responsibility for operation and maintenance,
- responsibility to inform each other of any changes affecting the

system or its performance,

- the intent of the agreement,

- recourse of the supplier concerning the state of repair or operation user's system if continued operation will adversely affect the supplier's equipment.

4 - COST SHARING AGREEMENT

This section defines

- who provides the funding for each part of the project,

- the amount, term and interest rate of any loans made for the system and the method and manner of repayment,

- provision for project cost overruns,

- termination rights of both parties.

5 - FINANCING

This section defines

- which party is to provide which part of project financing at what time.

6 - TERMINATION

This section defines

-the right of either party to void the agreement with suitable notice for reasons of default, nonperformance or nonpayment.

7 - TERMS OF THE AGREEMENT

This section defines

- the length of time in years that the agreement is to be in force.

This is normally equal to the life of the WHR/D equipment. The agreement can be renewed at the end of the specified term.

8 - PROVISIONS FOR FUTURE EXPANSION

This section describes the right of the supplier to expand the WHR system to serve future users.

9 - INDEMNIFICATION

This section defines

- limited liability of participants for claims, damages, losses due to performance or nonperformance in the execution of the agreement.

10 - TIME OF ESSENCE

This section defines

- that participants must act expediently to inform other parties to the agreement of any situation that would improve or impair their interests.

11 - GOVERNING

This section defines

- the prevailing law under which the agreement is legal and valid.

12 - NOTICES

This section defines

- the title and address of each participant's designated representative to or from whom notification must be sent.



APPENDIX C

LISTING OF WHR/D CONTRACTORS AND CONSULTANTS

CONTRACTORS

The following contractors have installed waste heat recovery/ distribution systems.

WESTERN AND NORTHERN

ADCO Power Construction Ltd.
10426 81st Avenue
Edmonton, AB
T6E 1X5
Telephone (403) 439-8549

HMW Mechanical Ltd.
2029 87th Avenue
Edmonton, AB
T6P 1L5
Telephone (403) 464-4034

J & R Mechanical Ltd.
Box 1541
Yellowknife, NT
X1A 2P2
Telephone (403) 920-2495

Nuclear Electric Ltd.
10355 59th Avenue
Edmonton, AB
T6H 1E7
Telephone (403) 436-8084

Backbay Welding Ltd.
5507 48th St.
Yellowknife, NT
X1A 1N9
Telephone (403) 873-5669

ONTARIO

N.W.D. Diesel Power Ltd.
1124 Waterford Street
Thunder Bay, ON
Telephone (807) 623-1681

NEWFOUNDLAND AND LABRADOR

Newfoundland, currently, has very few waste heat recovery installations.
The following contractors were selected on the basis of similar projects.

C & W Welding Ltd.
Bay Bulls, NF
Telephone (709) 334-2880

Buckingham's Machine and Fabricating Works Ltd.
P.O. Box 9444
St. John's, NF
A1A 2Y3
Telephone (709) 722-5902

Frelco Ltd.
Bldg 836 Harmon
Stephenville, NF
Telephone (709) 643-5668

CONSULTANTS

The following is a list of consultants who have worked on energy systems
in Canada's remote communities.

Acres International Limited
480 University Avenue
Toronto, ON
M5G 1V2

Apsco Engineering Ltd.
P.O. Box 270
Cremona, AB
T0M 0R0

Associated Engineering Alberta Ltd.
13220 St. Albert Trail
Edmonton, AB
T5L 4W1 (UNIES)

Ferguson, Simek and Clark Ltd.
4910 53rd Street
P.O. Box 1777
Yellowknife, NT
X1A 2P4

Ian Hayward & Associates
No. 1 1500 Marine Drive
North Vancouver, BC
V7P 1T7

M.M. Dillon Ltd.
47 Sheppard Avenue East
Box 1850
Station A
Willowdale, ON
M2N 6H5

B.J. Tworzyanski Ltd.
81 Cameron Road
Thornhill, ON
L3T 1N8

APPENDIX D**LIST OF REFERENCE PUBLICATIONS**

This reference list contains relevant publications. Several other well written manuals addressing specific project requirements may be available through the federal, provincial or territorial government energy departments.

1. **Remote Community Demonstration Program, Phase 1, Report Summaries** by EMR, 380 pages. This report summarizes overview studies prepared for remote communities across Canada as well as specific studies for designated communities. It presents several interesting energy options including WHR/D.
2. **Waste Heat Recovery Retrofit Project** by Ferguson, Simek, Clark Ltd. for Northwest Territories Public Works. The report describes the use of diesel jacket and exhaust heat to provide heating for a school at Lac La Martre, NWT. This well written technical document describes the systems, equipment and construction including preliminary design, system design, heating load analysis. For committees considering WHR/D, this report provides a good overview of all technical project considerations.
3. **A User Guide to Reducing the Costs of Operating Diesel Power Plants Under 500 kW** by M.M. Dillion Consulting Engineers for EMR. This is a very comprehensive guide covering numerous aspects of diesel operation and selection. WHR/D is technically described in detail with ample illustrations/photographs and specifications for heat recovery and distribution equipment. A detailed list of supplier's of heat recovery equipment is also included. Both customers and suppliers would find this manual useful for the pre-project investigation.

APPENDIX E

EXAMPLE WHR/D QUESTIONNAIRE

In using this questionnaire the following should also be considered.

1. Community finances.
2. Community economics.
3. Social Considerations.
4. Situation of the Community:
 - location of buildings,
 - any new planned developments,
 - growth rate of the community,
 - planned changes to power plant,
 - land obstacles between supplier and customer buildings,
 - would the system have to cross anyone's property?,
 - has WHR/D been discussed with the supplier?

EXAMPLE WHR/D QUESTIONNAIRE

This questionnaire is intended to help communities in evaluating their WHR/D potential. When completed, it will provide a reasonable first estimate of whether or not a WHR/D project would be beneficial, should be further developed.

A. Financial

1. Cost of Heating Oil \$ _____ per litre
2. List of Possible Heat Customers

List the three largest buildings in the community and the amount of heating oil used for each over one year. Multiply the cost of heating oil by the amount to get the Annual Heating Cost.

<u>Building No.</u>	<u>Name of Building</u>	<u>Annual Heating Oil Usage</u>	<u>Annual Cost of Heating Oil</u>
1	_____	_____ L	\$ _____
2	_____	_____ L	\$ _____
3	_____	_____ L	\$ _____

3. Calculation of Average Electrical Output

Determine the average electrical production from the diesel power plant over one year, _____ kW or divide the total kilowatt-hours produced over the year by 8760 hours, the number of hours in one year.

Average Electrical Production =

Average power plant output (kWh) = _____ kW
8760 Hours

4. Calculation of the Equivalent Displaced Oil

To determine the amount of heating oil the recovered diesel could displace in one year, multiply the annual plant electrical output by 0.0898, (0.0898 is for jacket heat recovery only, for

both jacket and exhaust heat recovery use a multiplier of 0.162).

$$\begin{aligned}\text{Equivalent Displaced Oil} &= 0.0898 \times \text{_____ kWh} \\ &= \text{_____ L}\end{aligned}$$

5. Cost of Displaced Oil

Multiply the amount of displaced oil by the current cost of oil.

$$\text{_____ L (of displaced oil)} \times \$\text{_____ cost per L} = \$\text{_____}$$

6. Cost of Recovered Heat

To determine the cost of recovered heat, assume the supplier will sell heat at 65% of the cost of the displaced oil.

$$\$ \text{_____ (cost of displaced oil)} \times 0.65 = \$ \text{_____ (cost of heat)}$$

7. Calculation of Possible Annual Savings

Subtract the cost of heat from the cost of displaced oil to get possible annual savings.

$$\begin{aligned}\text{Possible Annual Savings} &= \$ \text{_____ (Cost of Displaced Oil)} \\ &\text{less } \$ \text{_____ (Cost of Recovered Heat)} = \$ \text{_____}\end{aligned}$$

8. Application of the Recovered Heat

The quantity of displaced oil is compared with the amount of oil used by each of the three buildings. Depending on the size of the buildings and their heating requirement, the displaced oil may equal the total of all three or may only be enough to provide part of the heat for one building. The largest building, closest to the power plant should be selected.

Building Selected _____

9. Cost of a WHR/D Installation

The cost of WHR/D installation can vary between \$250/kW of average electrical plant output for new buildings to \$500/kW for modifications to existing buildings and power plant. For this example \$350/kW will be used.

Cost of Installation WHR/D = Average Electrical x \$350 = \$____
Output in kW

(This is for jacket recovery only, for both jacket and exhaust recovery add \$60,000 to the supplier's cost for each diesel.)

Assume the cost of the WHR/D installation is shared between the supplier and the user.

User's share of cost = 25% of Cost of WHR/D
= _____

Supplier's share of cost = 75% of Cost of WHR/D
= _____

10. Payback Period

To calculate the payback period for the supplier divide the suppliers share of cost of WHR/D by the cost of recovered heat.

Supplier's Share of Cost of WHR/D = _____ years
Annual Cost of Recovered Heat payback

To calculate the payback period for the user divide the user's share of cost of WHR/D by the possible annual savings.

$$\frac{\text{User's Share of Cost of WHR/D}}{\text{Possible Annual Savings}} = \text{_____ years payback}$$

This calculation assumes all the recovered heat can be used. If there is more recovered heat than needed the savings must be reduced proportionally to the amount of heat that can be used.

11. Financial Interpretation

If the payback for both the supplier and the customer is five years or less, the participants should look farther into developing a WHR/D installation.

B. Economic

A WHR/D project is a long-term consideration. In evaluating the benefits and costs of a WHR/D project, comparisons to other competing projects should include only those which will benefit the community over the next 10 to 15 years.

These projects should be listed and their respective benefits compared.

Consideration should be given to incorporating a WHR/D system into these projects to improve their benefits.

C. Technical

1. Are there any large obstacles between the selected buildings and the diesel power plant?
2. Are the heating systems of the selected building suitable for conversion to use of recovered heat? (Suitable heating systems are those which use two or three oil-fired boilers with forced circulation to distribute the heat.)

3. Can distribution pipes be run above ground or should they be buried? Can right-of-way be obtained?

D. Administration

1. List the minimum number of agencies that would need to be included in the WHR/D project and give reasons why.

Supplier

User

2. List the major concerns the community may have with a WHR/D project.

This completed questionnaire can be used to start meetings between the customer and supplier. Completing this questionnaire can be the first step towards a beneficial energy conserving WHR/D installation.

APPENDIX F

GLOSSARY OF TERMS, ABBREVIATIONS AND CONVERSIONS

Glossary of Terms

"as built" drawings	Design drawings of an installation which have been revised to show all changes made during construction and commissioning to the "approved for construction" design.
Capacity	In terms of electrical production, capacity refers to the maximum continuous power generated by the generation equipment.
Commissioning	The project work following completion construct are tested and brought into operation.
Jacket Heat	Heat extracted from the cooling system of a diesel engine.
Exhaust Heat	Heat extracted from the exhaust gases of a diesel engine.
Expansion Tank	A tank connected into a fluid system to accommodate the change in fluid volume caused by fluid temperature change.
Discounted Cash Flow	The savings or revenues from the operation of the WHR/D system, adjusted to today's present value using the discount rate.
Payback (Period)	The length of time in years required for savings or earnings from the operation of an investment to repay the cost of the investment.
Share Savings	Savings or earnings from the operation of a WHR/D system which are distributed in an agreed proportion to the user and the supplier.

Abbreviations

A	Ampere
Btu	British Thermal Unit
°C	Degrees Celsius
°F	Degrees Fahrenheit
ft ²	Square Foot
gal	Gallon
kWh	Kilowatt-Hour
L	Litre
L/y	Litre per year
RAO	Insulation resistance factor for insulation expressed as the reciprocal of the heat lost per degree of temperature differential

Conversions

1 kW	= 3412 Btu
1 ft ²	= 0.0929 m ²
1 m	= 3.2808 ft
°C	= 5/9 (°F - 32)
°F	= (9/5 °C) + 32

1 litre of heating oil contains 11.137 kW (38 000 Btu).